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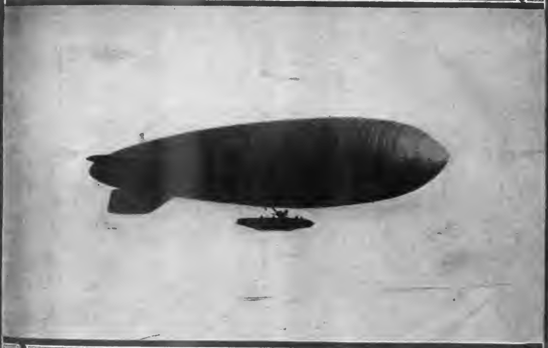

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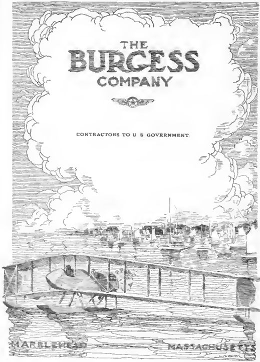
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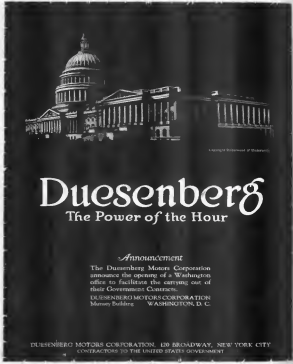
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VOL. V. NO. 7

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ISSUED ON THE FIRST AND FIFTEENTH OF EACH MONTH FORMS CLOSE FIVE DAYS PREVIOUSLY. ENTERED AS SECOND-CLASS MATTER, AUGUST 3, 1916, AT THE POST OFFICE AT NEW YORK, N. Y., UNDER ACT OF MARCH 3, 1879.

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Vol. V November 1, 1918 No. 7

The Krell Manometer

By A. A Merrill

A good practical manometer for use in air laboratories is that modification of the ordinary U-type known as the Krell. In this, one branch of the U is a glass tube set at a small angle and the other branch is a large tank. The movement of the meniscus in the tube gives a reading which, from the known dimensions of the instrument, can be turned into m.p.h. When calibrated to a standard, this type makes a good manometer for constant use in an air laboratory.

The question arises, is it not possible to modify this type so that it does not need calibration?

There are three possible errors in the Krell which are due to the fact that a change of level is measured by the movement of a fluid in a glass tube. Starting at point A the liquid is allowed to move to point B in the tube. Now the diameter of the tube at B may not be the same as the diameter at A, the axis of the tube at B may not lie in the axis of the tube at A and there may be an imperfection in the inner surface of the tube at B not present at A. Any one of these changes will necessitate calibration, and these conditions can not be eliminated because it is impossible to make glass tubing that is absolutely uniform throughout its length.

A glass tube has to be used, of course, because it is necessary to observe the position of the meniscus, but one important fact should be borne in mind. What we want to measure is *not the* movement of the meniscus in the glass, but its movement along a slope of known angle. Manifestly then what we must do is to move the *tube* along such a slope and never allow the meniscus to move in the tube. If we hold the meniscus at a fixed point in the tube and change the position of the tube on the slope we can measure the change of level directly from the observed movement of the tube. With such a manometer inequalities in the glass tube cannot affect the accuracy of our results.

There appear to be only two other sources of error, as follows.

1. If we take two glass tubes and connect them with a rubber U, put liquid in the tubes and then constrict the rubber U, both levels will rise. If there is a difference of levels this difference will not be altered, but the original levels will be altered. As in the Krell we measure from the original level, it is essential this level shall not be altered. If we let V represent the space occupied by the total volume of liquid and dV the reduction of that space due to the constriction, then if dV is very small in proportion to V the change of level is negligible. In practice I use a rubber tube two feet long for connecting the glass tube to the tank which rubber tube rests on the table. The movement of the rubber tube on the table does not, in fact, produce any visible change in the original level.

2. The shape of the meniscus will be altered by the wetness of the inner surface just above its level, therefore, it is advisable when the zero setting is being made to make the meniscus oscillate about the zero point in order that the surface of the tube near the zero point may be kept wet.

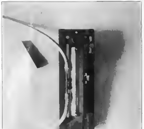


Fig. 1

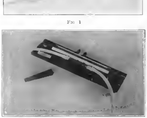


Fig. 2

The following description and photographs relate to a manometer which was designed by me and constructed in Pasadena under my direction. The instrument shown is a double manometer having a short scale of six inches which can be set by means of wedges and a level at angles of 3, 6 and 9 deg. For wind tunnel work one glass tube is attached to the Pitot and the other to the pressure plate, thus allowing the latter to be calibrated to the former. The lower ends of the glass tubes are connected to large tin cans, one of which is connected to the dynamic orifice of the Pitot and the other is open to the air. The can I used is an old five gallon oil can 9 in. square by 3 in. deep,

one side of which can be raised by a screw to get an accurate zero setting.

The formula for the Krell type, using so-called standard air,

$$\text{m.p.h.} = 45\,19\sqrt{\left(R\sin\alpha + \frac{R\sin\alpha}{K}\right)S}$$

where R is the reading in inches
α is the angle of the slope
K is the area of the tank — the area of the glass tube
S is the specific gravity of the fluid used.

Where K is large the term in which it occurs can safely be discarded. In my instrument K is about 2000.

On a slope of 6 deg. with alcohol of 0.81 specific gravity a reading of 6 in means a speed of 32 2 m.p.h.

With a magnifying glass the maximum error in reading is 1/200 of an in, which means 1/12 of 1 per cent error in a 6 in. reading. This equals 1/24 of 1 per cent error in V or an error of about 0 014 m.p.h.

In this manometer the glass tubes are fastened in brass blocks moved by hand, having an index passing over a steel K & E 6 in rule marked to 0 01 in. In the photograph the right hand brass block is shown without its glass tube. If higher accuracy of reading is desired a vernier or a micrometer screw can be used. Around each tube a line is etched forming a plane which determines the line of sight. The meniscus is kept constantly in contact with this plane.

The sensitivity of this instrument is not as great as is the sensitivity of either the Fry or the Chattock, but it is sufficiently great for all air laboratory work, and unless the V in the tunnel is very steady, the instrument is much more practical for constant use.

Cost of the Air Mail Service in August

The monthly report on the operation and maintenance of the Air Mail Service for the month of August, which is printed herewith, is of particular interest in view of the fact that it furnishes the first performance and cost data of the Standard-Hispano mailplanes (numbered 1-6). These machines, as is well known, were specially built for aerial mail carrying whereas the previously commissioned mailplanes, namely, the

I Operation and Maintenance

Airplane No.	Gas.	Grease and Oil	Office Force	Motor Cycles, Trucks	Rent, Light, Fuel Power, Telephone Water	Misc.	Pilots Actual Time	Pilots Dead Time	Hangar Men On Plane	Hangar Men Miscellaneous	Mechanics On Plane	Mechanics Shop Time	Repairs and Accessories	Interest on Investment	Departmental Overhead Charge	Total
38362	$86 90	$18 75	$18 27	$24 29	$29 08	$8 50	$81 07	$18 97	$31 21	$7 43	$72 87	$18 08	$3 06	$80 12	$61 50	$578 …
38363	65 70	7 98	13 27	24 29	29 63	0 50	25 98	18 97	31 21	7 43	52 38	13 08	13 96	80 12	61 50	451 …
38364	26 50	1 69	13 27	24 29	29 63	9 50	52 10	18 93	31 21	7 43	67 18	13 08	—	80 12	61 50	438 …
38367	81 50	6 02	13 27	24 29	29 63	0 50	93 31	10 38	37 26	7 42	113 72	18 08	15 96	80 12	61 50	602 …
38262	47 52	16 21	14 81	24 29	29 53	0 93	40 21	18 98	13 83	7 42	60 71	13 06	363 06	80 12	61 50	997 …
38274	123 87	44 45	14 81	24 98	29 64	9 50	107 21	18 95	13 83	7 42	146 98	13 09	345 27	80 12	61 50	1 043 …
38275	108 00	41 85	23 54	24 29	29 64	0 50	116 95	10 88	23 83	7 42	156 68	18 09	387 12	80 12	61 50	1 004 …
38278	103 87	22 64	14 81	24 98	29 64	9 50	104 45	10 88	13 83	7 42	131 43	13 09	152 98	80 12	61 50	802 …
1	117 95	26 88	18 04	24 29	29 63	9 50	177 44	15 85	10 98	7 42	139 25	13 09	139 87	80 12	61 50	808 …
2	80 90	[illegible] 27	13 27	24 29	29 63	9 50	188 98	10 98	25 93	7 42	117 90	13 09	4 80	80 18	61 50	673 …
3	52 80	11 13	13 27	24 29	29 63	9 60	102 06	16 98	25 93	7 42	121 64	13 09	28 30	80 13	61 50	590 …
4	63 56	8 01	16 40	24 29	29 64	9 50	73 95	16 98	18 08	7 42	172 85	13 09	26 80	80 12	61 50	639 …
5	16 50	6 71	13 27	24 38	29 64	9 50	23 23	15 98	25 93	7 42	111 34	13 09	4 30	80 18	61 50	440 …
6	72 45	26 87	13 27	24 29	29 64	9 50	205 71	16 98	25 93	7 42	118 28	13 09	37 45	80 13	61 50	740 …
Total	$1,071 84	$290 35	$206 37	$340 06	$414 91	$134 35	$1,388 58	$233 70	$347 84	$103 81	$1 564 74	$183 21	$1 129 48	$1 121 73	$861 00	$9,555 67

II Service and Unit Cost

Airplane No.	Gal of Gas.	Total Time Run Hr	Total Time Run Min	Total Miles Run	Miles Run per Gal of Gas	Cost per Hour	Cost per Mile
38362	288	11	19	898	2 80	$49 34	$ 6910
38363	219	7	—	629	2 87	64 45	7172
38364	95	3	28	313	3 29	123 05	1 3628
38367	272	10	36	847	3 11	56 66	7118
38262	158	10	13	654	4 13	98 32	1 0872
38274	438	30	59	1,853	4 23	33 81	5620
38275	354	22	—	1,344	3 79	45 64	7470
38278	340	25	32	1 713	5 03	31 43	4695
1	387	24	18	2 037	5 26	36 56	4365
2	273	14	28	1 410	5 18	46 70	4791
3	175	12	24	963	5 50	47 60	6131
4	209	11	11	773	3 69	56 67	8198
5	61	1	47	170	2 78	248 48	2 6067
6	241	17	48	1 608	6 66	41 39	4610
Total	3,510	203	01	15 120	4 30	$47 05	$ 6318

Curtiss-Hispano (series 38) and the Curtiss-Liberty (series 39), were merely military machines adapted for this purpose.

The present report discloses some highly interesting facts, particularly in comparison with the reports for June and July, which were published in the Oct 1, 1918 issue of Aviation and Aeronautical Engineering. The most striking of these is undoubtedly the gradually decreasing cost at which the service is being run, while the general efficiency shows a marked improvement.

Thus, the total cost of the service has decreased from $9,922.71 (in June) and $10,001 49 (in July) to $9,555 67 in August, and so have the repairs, from $3,569 50 to $2,504 82 and $1,320 46, respectively, although the number of miles flown has increased from 14,155 to 14,601 and to 15,120, and the number of mailplanes commissioned was 11 in June, 10 in July and 14 in August. While the total number of gallons of gasoline consumed has gone up from 2,787 to 3,211, and 3,510, respectively—which would seem obvious, considering the increased number of machines flown—the cost per hour of operation has decreased from $53 59 to $52 95, and $47 05, respectively, and the cost per flight mile has gone down from $0 70 to $0 68½, and $0 63, respectively.

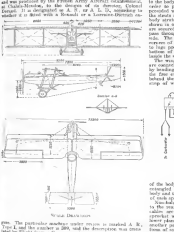
In view of these gratifying figures it may come as a surprise that the miles run per gallon of gasoline should show a decline, dropping from 5.07 (in June) to 4 54 (in July), and 4.30 in August. It should, however, be noted that this decline can in no way be imputed to the greater or lesser efficiency of the mailplanes, or of their engines, because the number of miles flown per gallon of gasoline is obviously dependent, to a considerable degree, if not entirely, on weather conditions. Therefore it may be expected that with the coming of the bad season the operation of the air mail service will show a further decline in the matter of gallon-miles.

With respect to the new Standard Hispano mailplanes, it is interesting to note that one of them, No 6, has made the best showing in gallon-miles, since the establishment of the air mail service, averaging 6 66 gallon miles, the best previous average, 5 90 gallon-miles, having been established in June by the Curtiss Hispano mailplane No 38276.

Following its usual practice, the Post Office Department does not estimate depreciation in this report for lack of convincing data, but this is reflected in the items under repairs, parts and labor. Items for rent, light, power, etc, miscellaneous, dead time of pilots, time of hangar men, shop time of mechanics, interest on investment, and departmental overhead charges all of which are not directly apportionable to individual ships are pro-rated equally between all of the ships.

The French A.R. Type I Biplane

This machine belongs to the general service class of airplanes and was produced by the French Army Aircraft establishment, at Chalais-Meudon, to the designs of its director, Colonel Dorand. It is designated as A. R., or A. L. D., according to whether it is fitted with a Renault or a Lorraine-Dietrich engine. The particular machine under review is marked A. R., Type I, and the number is 399, and the description was translated by *Flight* from a German contemporary.



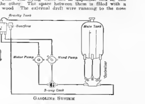
Scale Drawings

The machine is a two-strutter biplane of 13 30 m. span, and has its body supported between the planes on ash struts. Sweep-back and dihedral angle are only present in the lower plane. The former amounts to 1 deg., while the dihedral angle is 2 deg. The top plane is staggered backward 0 5 m. The gap is 1.825 and 2 m. respectively, that is to say, in the center it is 0 945 of the chord. The angle of incidence of the upper plane is 2.5 deg., that of the lower plane 3 deg.

The halves of the wings are screwed together in the center of the machine. The wing spars appear to be of I section, covered on both sides with three-ply. Between every two ribs, whose spacing is 300 to 340 mm, is a short false rib on the top surface only, running from the leading edge to the front spar. The wing fabric, which is of a cream color, is sewn to the ribs. In front of the trailing edge, which is formed by a wire, as in all French machines, eyelets are incorporated

The plane struts, which, with the exception of those secured to the body, are of stream-line form. In order to prevent lateral bending, the outer plane-struts are provided with a peculiar bracing. In addition, the middle of the struts are braced to one another and to the bottom of the body struts. The strut fittings are of a very simple type, as shown in one of the illustrations. Strut sockets of sheet steel are secured to the spars by U bolts, the two shanks of which pass through the spar and are secured by nuts on the other side. The flying wires and landing wires are anchored to the corners of these U bolts, while the incidence wires are secured to lugs projecting from and forming part of the steel plate bottom of the strut sockets. This bottom is simply resting inside the socket and is not secured in any other way.

The wing bracing consists of solid wires throughout, which are connected to the fittings and turnbuckles in the usual way by bending them over and sliding a ferrule of spiral wire over the free end. The flying wires are in duplicate and lie one behind the other. The space between them is filled with a strip of wood. The external drift wire running to the nose

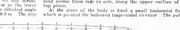


Gasoline System

of the body is wrapped with thin cord to prevent it becoming entangled in the propeller in case of breakage. Between the body and the lower plane there is diagonal bracing in the plane of each spar.

Non-balanced ailerons, positively operated, are hinged direct to the rear spar of the top plane only. The aileron control cables are in the form of simple cables running from the sprocket wheel on the control column, around pulleys in the lower plane, along the lower side of the lower plane and under another pair of pulleys. From this point on they are in the form of solid wires of 2 mm. diameter, running to the aileron crank levers, which are in the form of quadrants. The upper cranks of the ailerons are connected by cables and wires running across from side to side, along the upper surface of the top plane.

At the stern of the body is fixed a small horizontal fin to which is pivoted the balanced trapezoidal elevator. The rudder



Section of Elevator

is also balanced. The rudder post is braced to the elevator, and this in turn to the body, by stream-line steel tube struts. The ends of these struts are flattened out and bolted to the various fittings. There is no vertical fin. The rudder is controlled by plain wires of 2.5 mm. diameter. Only where they pass over pulleys have cables been substituted for the wires.

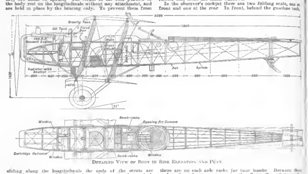
The undercarriage struts are secured to the spars of the lower plane at the points where occur the attachments for the struts running to the body. The short body struts are braced by stream line tubes fore and aft to the body. The one-piece axle rests between two cross struts of steel tube. The travel

of the axle is not restricted The undercarriage is braced diagonally in the plane of both pairs of struts.

The longitudinals and struts of the body, which is fabric covered, are made of ash up to the observer's seat From there they are made of spruce. The struts of the rear portion of the body rest on the longitudinals without any attachment, and are held in place by the bracing only. To prevent them from

a three-way cock, as well as the trimming gear for the elevator On the left are the levers for advancing or retarding the ignition, the gasoline and air levers, the radiator shutter control and the oil cock. In the floor of the body, in front of the rudder bar, there are small windows.

In the observer's cockpit there are two folding seats, one in front and one at the rear In front, behind the gasoline tank,



Detailed View of Body in Side Elevation and Plan

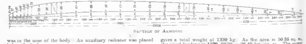
sliding along the longitudinals the ends of the struts are notched to correspond with the shape of the wiring lugs, which surround the longitudinals.

The 8-cylinder, Vee-type Renault develops, according to a plate in the pilot's cockpit, 190 hp at 1550 to 1600 r p m The radiator is placed between the body and the lower plane There is a shutter arrangement for varying the cooling A water collector or tank is placed above the port row of cylinders The exhaust gases are carried outward to each side through short collectors. With the older, the exhaust from both rows of cylinders was carried inward to a common collector carrying it up above the top plane, an arrangement which greatly hampered the view of the pilot In these machines the radiator

there are on each side racks for four bombs Between these racks, through an opening in the floor, the photographic camera can be inserted A shelf for plate holders is placed behind the port bomb racks.

The pilot is armed with a fixed machine gun, placed on the right-hand side above the body, and is operated from the left cam shaft Firing is accomplished by Bowden control from the control wheel. The observer has two movable machine guns, coupled together and mounted on a gun ring with elevating arrangements

The weight of the machine, empty, was ascertained to be 890 kg An inscription on the rudder states that the weight of the fuel is 140 kg, and that the useful load is 300 kg. This



Section of Aerofoil

was in the nose of the body An auxiliary radiator was placed below the body

The engine is bolted to two channel section steel bearers, which rest on strong sheet steel cradles. Immediately behind the engine is placed transversely the oil tank, which has a capacity of 7 liters. The main gasoline tank, which has a capacity of 170 liters, is divided into three compartments, and is placed behind the pilot's seat From here the gasoline is pumped into a small gravity tank holding 12 liters and placed behind the engine For this is employed either a pump driven by the engine or a hand pump to the right of the pilot If too much gasoline is pumped through it is returned to the main tank via an overflow

On the instrument board in front of the pilot are the following instruments A cooling water thermometer, ignition control, compass, petrol cock and revolutions indicator To the right, at the side of the seat, is the gasoline hand pump with

gives a total weight of 1330 kg As the area is 50 36 sq. m, the wind loading is 1330 50 36 = 26 40 kg sq m The power loading is 1330 190 36 = 7 0 kg /hp

The chief aim of the designer appears to have been to provide a light machine with low wing loading. The construction of the details such as fittings, wiring, lugs, etc, has therefore been kept very light and simple

Item Weights—Engine, 245 kg ; cooling water, 25 kg, air screw, 22 kg, one fuel main tank, 22.5 kg ; one fuel gravity tank, 2 kg, one oil tank, 2 kg, engine accessories, exhaust collector, body, etc, 244.5 kg, under-carriage, 60 kg, controls, 6 kg., wings, 234 5 kg, bracing, 26.5 kg, weight, empty, 890 kg, total weight, 1330 kg

Loads—Pilot and observer, 150 kg, armament, 75 kg, four bombs at 12 kg, 48 kg, wireless and camera. 27 kg. 182 liters gasoline and 7 liters oil, 140 kg, total, 440 kg

Weight of Wings—4 65 kg /sq m

Stresses in Airplane Ribs*

Transverse Testing Under Non-Uniformly Distributed Load with Special Application to Airplane Wing Ribs

By Irving H. Cowdrey

The work of the testing engineer is very largely that of qualitative determinations. A glance through the standards formulated and adopted by this Society will bear out this statement to the fullest. While it is true that certain specific methods of test have been devised and standardized with an attempt of reproducing in the laboratory the conditions existing in practice, these instances are comparatively rare.

That tests are continually made on specimens which in no wise resemble the form or size of the members appearing in the finished structure is not to be offered as an argument in any sense derogatory to the value of the results obtained. Whenever the structure is of such form and the loads of such a nature that the stresses in each member are determinate, specimens of the usual laboratory form may, with all propriety, be tested and the results used to determine the fitness of the material under consideration for the purpose intended.

There are, however, many types of structures in which the stress distribution between the various members and parts is very difficult or impossible to determine with the present engineering knowledge Again, even though the load applied to the individual member may be known with a fair degree of accuracy, it is possible that the form or construction of the member itself may be such that the variations of stress through its different parts may not yield itself to the usual methods of calculation.

To this latter class belong many of the members entering into the construction of the frame of the airplane Many experiments have been made to determine the forces acting on its aerofoils and other surfaces. Hence if the craft or any of its parts could be considered as a body of even approximate rigidity the stresses set up in most of its members could be calculated with some degree of precision Morever, if its parts were fabricated from a material that obeyed perfectly the laws of elasticity and whose modulus of elasticity was known and constant, the stresses could be determined according to the methods common to the theory of elasticity Such is, however, not the case The structure is largely of wood, selected and seasoned it is true, yet possessing much of the variability of this material Again the fittings, and types of attachment, the stays and adjusting devices are all of such a nature that exact calculations are difficult if not impossible The secondary stresses induced in such a frame are a matter of very doubtful speculation

This condition has lead to some attempts to test certain of the completed portions of the craft The results have doubtless been instructive in some instances, but the writer feels that many of the tests made prior to the last year have been of very doubtful value About a year ago it was suggested to the writer by Mr Alexander Klemin, now connected with the U S Signal Corps, that some tests should be made to determine the relative values of certain methods of airplane wing rib construction The problem seemed of such scientific, engineering, and timely interest that the matter was taken under careful consideration In the development of the method described later in this paper, much very valuable assistance was rendered by Prof Harrison W Hayward and Mr Ralph G Adams, colleagues of the writer in the Testing Materials Laboratory of the Massachusetts Institute of Technology, where the tests were conducted

Such tests as had been made up to that time, so far as the writer and his colleagues were aware, had been quite absurd A few futile attempts had been made to obtain the strength of ribs by supporting at two points and loading with a single central load. The absurdity of such tests must be perfectly apparent to anyone familiar with airplane construction and the type of load to which these ribs are subjected In any test it must ever be kept clearly in mind that the value of the results depends not only upon accuracy of observations, but

*Presented at the twenty first annual meeting of the American Society for Testing Materials held at Atlantic City, June, 1918

equally upon the ability of the experimenter to reproduce in the laboratory conditions which are, as nearly as may be, identical with those to which the member under investigation will be subjected in practice

The Problem

The acceptance of the above premise necessitates, before all, the consideration of the manner in which the member is attached to the remainder of the wing frame, and the de-

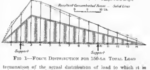


Fig 1—Force Distribution for 150-lb Total Load

termination of the actual distribution of load to which it is subjected during flight

The member itself is of great frailty, a rib five feet long weighing but nine ounces This at the start introduces an element of somewhat unpleasant complication. To apply to such a member, whose transverse dimension is about one-half inch, a load which shall approximate in any degree that produced by wind pressure against a canvas covering offers some very interesting problems. Moreover this load is not only distributed but distributed non-uniformly. The problem to be solved seemed after some consideration to divide itself into the following heads which will appear in the same order in the subsequent discussion:

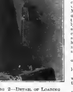


Fig 2—Detail of Loading Device

1 Methods of support or suspension,
2. The distribution of load,
3. Application of load with the proper distribution,
4. Accurate measure of the load, and
5 Determination of the distortion of the member under test.

1 *The Method of Support or Suspension*—In the completed wing, the ribs are connected by one or more continuous spars, passing from tip to tip of the wing This affords secure lateral fastening at these points. To duplicate such a condition, the ribs were cut from a group or so fabricated as to leave in place a piece of spar about one inch thick

This spar section may be seen at *A*, Fig 2 In the cases furnishing data for this paper the two-spar suspension was used To each of these spar sections was fastened a pair of

steel plates 1/8-in. thick, each plate having in its center a 5/8-in. hole. The fastening was accomplished by means of four 1/8-in. steel studs having a nut on each end. These studs appear at A, Fig 3, and the hole for one of them may be seen at I, Fig 2. With these plates in place a 5-16-in. hole was bored through the wood to line as nearly as possible with the 5/8-in. hole in the steel (see 2, Fig 2). The holes in the wood were then reamed so that a 3/8 in. bolt with a finished shank could be just forced through by hand pressure. These 3/8-in. bolts served then as the points of suspension and from them straps (B, Fig 3) were carried to the maple plank (C, Fig 3), which in turn was suspended from a pair of chain falls. The suspension bolts were set up as tightly as possible without producing slumping action between the suspension straps and the side plates on the rib. This was to afford as much lateral support as possible without interference with freedom of vertical deflection under load.[1]

2. *The Distribution of Load.*—The very nature of the purpose of the airplane wings indicates a distributed load. The exact distribution was not investigated by the writer. Many experiments have been carried out to determine the intensity of pressure on the various parts of aerofoils under flying conditions. It is not the purpose of this discussion to comment upon the results that have been thus obtained. It is assumed that the diagram for the distribution of load on a rib is such as is indicated in the work by G. Eiffel, entitled "La Résistance de l'Air et L'Aviation," and reproduced in the translation of the above by J. C. Hunsaker. These load diagrams show that the distribution varies under the varying conditions of flight, both in general outline and in the position of maximum intensity. Under such circumstances a representative load diagram must be arbitrarily chosen. For the purpose of these tests it was assumed that a straight-line diagram would be a satisfactory approximation. Moreover, it was assumed that the point of maximum intensity could reasonably be assumed at a distance of one-fifth the chord length from the leading edge of the wing.[2] (Shaded area, Fig 1.)

Such a distribution, as well as the general dimensions of the members, precluded the possibility of anything in the line of sand or hydraulic cushioning. Hence, a truly distributed load seemed impossible. With the member under test the total length was 60 in. A load, more or less concentrated, applied at each 4-in. interval giving 14 points of loading, could be presumed to give a fair approximation to the distributed load desired, provided these individual loads be properly proportioned.

There have been some experiments made within a very few months in which but eight loading points have been used. To the writer this number seems entirely too small. The common methods of construction provide for the entire removal of the web of the rib at frequent intervals. A reference to Fig 3 will show the extent of such removal in the type of rib under test. The portions of the rib over one of these spaces act like secondary beams under load. A number of loading points less than was used in the tests under consideration produces, in the writer's opinion, very serious effects on the stress distribution throughout the rib. It would seem that the number of loading points should be greater than those used in this case rather than less.

Fig 3—Apparatus for Testing Wing Ribs, Non-Uniform Load Distribution

Using the number of loads noted above, the problem of proper proportionment was attacked as follows. The load diagram for a total load of 150 lb is divided into 14 parts (see Fig 1). The ends are triangles with bases each 2 in. long. The remaining divisions then take the form of trapezoids, with the exception of division 3. Each division has a 4-in. base. Each of these areas then represents the load distribution desired over a length bounded by its extreme ordinates. The computed resultant for each of these areas appears below

Load No.	Load Lb.
1	7.5
2	13.8
3	19.9
4	18.3
5	16.7
6	15.5
7	12.2
8	11.7
9	10.0
10	7.2
11	6.7
12	5.0
13	3.3
14	1.3

The application of concentrated forces according to the above schedule then should give a loading quite comparable with that indicated by the straight-line diagram. Theoretically, these fourteen concentrated forces should be applied at the centers of gravity of the respective areas. This has been done for numbers 1 and 14. In the other instances it has been assumed that the middle ordinate is sufficiently near to the center of gravity. This introduces an error of from 0.03 to 0.17 in. in the location of these resultants. In the case of the larger central forces the error in location is least. These resultant forces are shown as solid lines in Fig 1. To aid in a comparison to be made later their ends are having been joined by a solid line.

3. *The Application of Load with Proper Distribution.*—The problem now resolves itself into one of the simultaneous applications of fourteen different loads. Not only must the application be simultaneous, but the rate of increase in the applications of each load must be such that under any total load whatever the relation between the various forces must be the same as the relation shown in the above tabulation. If the problem were solely that of applying the loads without the complication of absolute adherence to the maintenance of this relation, the solution would be quite simple. The familiar expedient of pouring shot or sand into a bucket would suffice. But to make a device to deliver sand or shot simultaneously into a large number of buckets, and into each at a different and definitely predetermined rate seems scarcely practicable. Again, if the number of loading points were made a power of two, and perhaps limited to eight in number, some modification of the scheme so commonly used in multiple-point loading of large beams could be arranged. This method is quite complicated with 8-point loading and becomes doubly complicated with 16-point loading, which is the next step in such a method. With all this in mind, careful consideration led to a complete discard of all such methods and the final adaptation of what the writer believes to be a new departure in load application. It was felt that the most satisfactory solution of the problem could be reached by the application of load through a series of rubber bands of uniform properties whose widths should be made directly proportional to the load each band was expected to supply. These bands were obtained by cutting sections from a motorcycle inner tube. The particular tube used was of red rubber for a 28 by 3-in. tire.

With such an ideal series of bands, let one end of each be fastened to a rigid support, such as E, Figs 2 and 3, and the other properly attached to the rib under test. The suspension of the rib as already described will permit it to be raised while a level (D, Fig 3) enables a proper horizontal alignment of the supports. Under such conditions, neglecting the deflection of the rib itself, the fourteen loads will be applied at the predetermined points and with exactly the predetermined distribution.

In the device as illustrated by Figs 2 and 3 the attachment of the bands is as follows:

Into the timber E are screwed at K heavy screw eyes of a size proper to take a 1/4 in. stove bolt. Each pair of eyes are so spaced transversely on the timber that they permit on the bolt, between their inside faces, a pair of washers between which is a thin brass tube of a length equal to the width of the

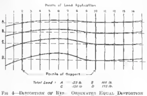


Fig 4—Distortion of Rib. Ordinates Equal Distortion with Respect to a Datum Line Through Points of Support, Ordinates Full Size

rubber band, R, which is to be used at that particular loading point. This gives the rigid fastening for one end of the band. Two 1/8-in. hard brass wires, G, with a soldered eye (L, Fig 2) in the lower end of each, H, and threaded at the upper end, pass through a small wooden block at F. On the upper side of F washers and nuts (N, Fig 2) afford a ready means of adjustment of the length of this stirrup-shaped device. A stove bolt with tube and washers (O, Fig 2) passes through the eyes of the wire rods. Such device affords a proper means of attachment between the upper end of the rubber band and the member under test. The proper adjustment of these stirrups will be discussed under "Notes, Suggestions and Precautions."

4. *Accurate Measurement of the Load.*—As will be readily seen from Fig 3, the heavy timber E (in this particular test a 6 by 6-in. hard pine stick weighing about one hundred pounds) rests on platform scales, S. On each end of this timber are three 50-lb weights W. With no tension in the bands R, the tare weight of the timber and weights is read on the scales. The plank C is raised and maintained level, then stretching the bands and hence applying to the rib, loads according to the predetermined schedule. The summation of these fourteen loads may be obtained at any instant by balancing the beam of the scales and noting the difference between the reading obtained and the original tare weight. The accuracy of this determination depends solely upon the accuracy of the scales. This should usually be within a half pound.

Scales of the ordinary platform type were used in this method of test for two reasons. First, in the opinion of the writer a greater precision can be thus obtained than with any of the forms of testing machines commonly employed in laboratory work; second, it was desired to produce a method of testing that could be carried out easily by the manufacturer and permit and encourage experimental work on rib design by those who are not privileged to have at their disposal a properly equipped laboratory.

5. *Determination of the Distortion of the Member under Test.*—It is believed that the actual strength of a wing rib is but a partial solution of the problem at hand. The writer would not pose as an expert in aerodynamics nor in airplane design, yet to any engineer of analytical turn of mind the question of the effect of wing distortion must present itself. If the wing surface changes appreciably under conditions of flight, does it not seem possible that some of the expectations of the designer may fall far short of fulfillment? If the designer expects so much lift, so much drift, and such a center of pressure, what unsuspected factor enters into the problem through the possibly unforseen distortion of his aerofoil?

The possible importance of rib distortion would seem to make such determination a requisite adjunct to any satisfactory method of test. However, in view of the fact that many variables in the line of material and workmanship enter into the fabrication of each rib, it would seem that undue precision in the distortion determination is neither necessary nor advisable. A precision of 0.01 in. is doubtless satisfactory and such precision is possible with the device under consideration.

Throughout this discussion it is assumed that any distortion of the timber E which may occur is of such magnitude as to be absolutely negligible. As the plank C is raised the rubber bands become elongated. This elongation is measured by means of dividers set in center punch marks in the ends of the stove bolts, H, K, etc. If there were no distortion of the rib, the increment of length of all bands would be the same under any given total load. Such is found not to be the case. For the particular test under discussion, these increments of length for loads of 50, 100, 150 and 175 lb., respectively, will be found in Table I. In Fig 4 these increments of length

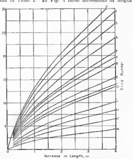


Fig 5—Calibration Curves for Rubber Bands

have been plotted from arbitrary reference lines not shown. Now points 2 and 10 are the points of suspension as well as loading points. Hence so far as the rib is concerned these are points of zero deflection.

In each curve of Fig 4, straight lines have been passed through the intersections of the curve with these two ordinates. Such lines serve then as lines of reference from which the actual distortion of any part of the rib may be determined for the particular load in question. The distortion curves are drawn showing the rib in its true position in flight. It will be noted that with the load distribution assumed, the particular rib under investigation showed a noticeable droop of the leading edge with a corresponding up-tilting of the trailing edge. Whether this distortion is of a magnitude and nature to affect the aerodynamics of the craft in flight is not within the province of this discussion. In the interpretation of these curves it must be borne in mind that while the ordinates are plotted full size, the chord length of the rib is vastly contracted.

[1] The method of suspension here used does not perfectly duplicate the supporting of the ribs in the frame of the wing. The attachment of the fuselage to the spars is such that twisting of the spar at these points is prevented to a large degree. Actual conditions would then possibly be more accurately reproduced if the straps B, Fig 3 were clamped to the spar section in place of the intermediate side plates at these points.

[2] Some tests have been made by various experimenters since those here described in which the point of maximum load intensity is further from the leading edge. In some of the design calculations this point is taken at mid-chord instead of as indicated above.

TABLE I.—DETAILED LOAD INVESTIGATION

Band No.	Initial Reading, in.	Load by Scales, 50 lb: Length, in.	Increase in Length in.	Force from Curves, lb	Load by Scales, 100 lb: Length in.	Increase in Length, in.	Force from Curves lb	Load by Scales, 150 lb: Length, in.	Increase in Length in.	Force from Curves, lb	Load by Scales, 175 lb: Length, in.	Increase in Length, in.	Force from Curves, lb	Band No.
1	2.47	2.87	0.40	3.4	3.45	0.98	8.2	4.38	1.91	9.1	4.96	2.49	19.7	1
2	2.50	2.98	0.38	4.4	3.50	1.26	8.7	4.34	1.84	12.6	4.96	2.46	14.7	2
3	2.47	2.80	0.33	6.7	3.30	0.82	12.5	4.23	1.76	10.1	4.81	2.34	23.7	3
4	2.47	2.80	0.33	6.2	3.37	0.90	11.4	4.20	1.73	17.7	4.75	2.28	20.7	4
5	2.47	2.80	0.33	4.8	3.35	0.88	10.4	4.17	1.70	18.6	4.73	2.26	18.8	5
6	2.53	2.84	0.31	4.1	3.41	0.88	8.3	4.22	1.69	13.6	4.78	2.23	17.8	6
7	2.54	2.82	0.28	3.7	3.41	0.87	8.1	4.21	1.67	12.2	4.79	2.25	14.6	7
8	2.53	2.84	0.31	3.8	3.40	0.63	7.6	4.29	1.76	11.1	4.87	2.34	13.2	8
9	2.53	2.96	0.24	2.3	3.50	0.98	6.8	4.37	1.85	8.6	4.38	2.44	11.7	9
10	2.52	2.88	0.36	2.6	3.52	1.00	5.7	4.40	1.88	6.8	4.99	2.47	10.0	10
11	2.53	2.87	0.34	1.8	3.51	0.98	4.3	4.37	1.84	6.4	4.99	2.46	7.8	11
12	2.55	2.89	0.34	1.6	3.55	1.00	3.5	4.40	1.85	5.3	5.00	2.45	6.3	12
13	2.58	2.93	0.35	1.3	3.58	1.00	6.7	4.44	1.86	4.1	5.03	2.48	4.8	13
14	2.52	2.84	0.33	0.7	3.51	0.98	1.8	4.38	1.86	2.7	4.96	2.44	3.2	14
			Sum	46.4			99.2			148.5			176.5	
			Discrepancy	−7.2%			−0.8%			−1.1%			+0.9%	

Checking the Load Distribution.—While there was every reason to believe that the method of loading described in the previous pages would yield a load distribution quite closely in accord with that indicated by the diagrams of Fig. 1, still it seemed desirable to check the loads as carefully as might be. Such a check investigation is described in the following text.

Each band, after being cut to the proper width, was calibrated to determine the load-elongation relation through and somewhat beyond the range expected to be used in the rib test. These calibration curves appear in Fig. 5. For convenience in use, the increment in length has been plotted as abscissa rather than the actual length of the band. It should be noted, however, that the original length of the bands varied not over 0.02 in. The "band number" refers to the position of the band in question in the loading scheme (see Figs. 1 and 4). During the test, as has been previously noted, readings were made so that the increment in length is known for each band at each of the four specific loads investigated.

This increment, by reference to the calibration curves of Fig. 5, makes it possible to determine the force applied at each of the fourteen loading points. For any given set of readings, the sums of the individual forces thus determined should, of course, check with the summation as indicated by the reading of the scale beam. The closeness of this check between the apparent and actual summation is indicated in Table I. With the exception of the 50-lb. load investigation the discrepancies average about 1 per cent. It is only to be expected that the discrepancy for very small loads will be large due to the difficulty in making accurate interpolations on the calibration curves.

A detailed comparison has also been made between the computed and applied forces for a total load of 150 lb. Such comparison is shown graphically in Fig. 1. The forces as determined by the calibration curves have been plotted in the figure and the ends of ordinates thus obtained are joined by the dotted line. The closeness with which this follows the solid line joining the ends of the ordinates representing the desired forces would indicate that the method which has been herein discussed should prove satisfactory for this type of investigation.

Notes, Suggestions and Precautions

Preliminary Adjustment of Stirrups.—It is necessary to make a very careful adjustment of each stirrup before attaching the rubber bands, in order that when the plank and rib are raised for the application of load, each band shall start elongating at the same instant. The most satisfactory of the methods tried is as follows: Lower the rib until the lowest point of the bottom edge will clear the timber *E*, Fig. 2, by some convenient amount. A single bolt should now be passed through the eyes in the timber *E* and through the eyes of the corresponding stirrup. By means of the adjusting nuts *F*, the stirrup may be brought to the proper length. When each stirrup has been thus adjusted, the level *D* should be set by means of the slotted end fastenings, so that the bubble will be in the center of the glass.

With all the above precautions observed, the stirrups may be released from their companion eyes, the rib and attachments raised and the rubber bands put in place.

The Rubber Bands.—The tube from which these bands were cut was of uniform thickness throughout. This uniformity is very convenient, since less care is necessary in adjusting the bands than would be requisite if the thickness varied as is the case with some types of tubes. It is believed that in cutting bands from a tube, as was done in this investigation, the width may be obtained accurately to about 0.01 in. In choosing the scale of width there are two antagonistic conditions to be considered:

1. It is desirable that the length increment of the band under load should be large compared with the deflection of the member under test so as to minimize the error in loading due to the variation in length increment of the various bands.

2. The maximum load applied by any band should probably not exceed one-fifth the strength of the band. This would be somewhat dependent upon the quality and resiliency of the material used.

The bands used in this test were of material showing a strength of about 125 lb. per inch of width when tested as a band. The elongation at fracture was about 1000 per cent.

It would seem feasible to substitute for bands cut to a predetermined width as in this case, some of the better grades of para rubber bands, which may be purchased in definite sizes. Combinations of such bands could be used in parallel.

TABLE II.—CALIBRATION OF RUBBER BANDS

Band No.	Length Increment in.	Load, lb.: October	April		Variation, lb.
1	1	6.1	6.3		+0.2
	2	8.3	8.4		+0.1
	3	11.8	12.0		+0.2
	4	14.1	14.6		+0.5
				Aver.	+0.25
3	1	13.1	13.6		+0.5
	2	20.6	20.8		+0.2
	3	28.3	28.6		+0.3
	4	31.6	32.2		+0.6
				Aver.	+0.40
5	1	11.4	11.5		+0.1
	2	17.4	17.4		0.0
	3	22.0	22.2		+0.2
	4	26.8	27.1		+0.3
				Aver.	+0.15
7	1	8.8	8.8		0.0
	2	13.4	13.4		0.0
	3	17.1	17.2		+0.1
	4	20.8	21.0		+0.2
				Aver.	+0.08
9	1	6.7	6.5		−0.2
	2	10.1	9.9		−0.2
	3	12.8	12.7		−0.1
	4	15.8	15.8		0.0
				Aver.	−0.13
11	1	4.3	4.4		+0.1
	2	6.8	6.6		−0.2
	3	8.4	8.5		+0.1
	4	10.3	10.2		−0.1
				Aver.	−0.03
13	1	2.9	2.7		−0.2
	2	4.3	4.3		0.0
	3	5.4	5.5		+0.1
	4	6.7	6.8		+0.1
				Aver.	0.00

The 300 Horsepower Maybach Engine*

Cams and Camshaft.—Both the inlet and exhaust cams are of the same profile, although the valve lift is slightly greater for the exhaust valves, a difference which is due to the unequal tappet clearances. Details of the cam design are given in Fig. 11. The cams are made in pairs, machined from solid forgings. Each pair of inlet or exhaust cams is fitted to the camshaft separately. Each camshaft is provided with three keyways, which are machined along the whole length of the shaft. The cam blocks are made with three keys cut inside the hole which is bored in the cam blocks, the keys being solid with the cam. The cam blocks are also fixed to the camshaft by taper pins to prevent lateral movement. The central portion of each cam block between each pair of cams is machined to a diameter of 49 mm. × 16 mm. in width. These portions of the cam blocks form the journals of the camshaft bearings. They run in plain phosphor-bronze bushes let into the top half of the crank chamber, and helical oil grooves are cut in the face of the bearing journals on the camshaft. Each cam block is also fixed in position in the camshaft by one 5 mm. set screw, which prevents the cam from moving laterally in the keyways.

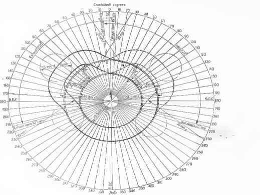


Fig. 11. Cam Profile and Valve Timing

The five bronze bushes forming the camshaft bearings are pressed into the crankshaft bearing webs of the crank chamber; the front and rear camshaft bearings are fitted with a flange, and are detachable; they are twice the width of the other three on account of the camshaft driving gears which are fitted on the front end of the camshafts, and the magneto driving gears, which are fitted to the rear ends of the camshafts.

Crankshaft.—Details of the design of the crankshaft are given in the dimensioned drawing in Fig. 12. The crankshaft runs in seven plain bearings lined with anti-friction metal of the usual formation. All the journals are 66 mm. in diameter

* Continued from last issue

Fig. 12. Details of Crankshaft

The diameter of the crankpins is also 66 mm The crank-webs are all of the same section, being 23 mm. in thickness and 95 mm in width across the face All the journals are bored 36 mm diameter. The crankpins are bored 39 mm. diameter,

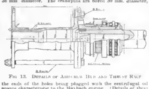


Fig 13. Details of Airscrew Hub and Thrust Race

the ends of the holes being plugged with the centrifugal oil scoops characteristic to the Maybach engine (Details of these are dealt with later in the notes on lubrication) The rear end of the crankshaft carries the extension shaft, on which is mounted the wireless dynamo driving pulley, which embodies a friction clutch This design of wireless pulley is a standard German engine fitting, full details of its design and construction have already been issued in previous reports.

The extension shaft referred to above is a driving fit in the rear end of the crankshaft, which is bored 42 mm., the extension shaft is locked by a 7 mm. taper pin Two centrifugal oil thrower rings are machined on the extension shaft

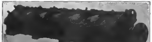


Fig. 14. Top Half of Crankcase

The main driving bevel gear is fixed to the rear end of the crankshaft by a key 8 mm. wide × 5.5 mm deep, half sunk in the shaft

An interesting point in the design of the crankshaft is found in the method of fixing the flange to which the airscrew hub is bolted. The construction is clearly shown in the sectional arrangement of the airscrew hub in Fig 13, from which it will be seen that a slight taper, 1 in 33.3 mm, is machined on the

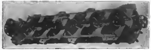


Fig 15. Inside View of Crankcase, Top Half, Shown Upside Down

front end of the crankshaft, on to which the airscrew hub flange is very tightly driven. No key is fitted to the taper, but a grub screw 10 mm diameter is screwed into the front end of the flange, the hole being drilled half in the flange and half in the crankshaft.

The grub screw is locked by the flanged head of a large plug 40 mm. diameter, which is screwed into the hollow front end of the crankshaft. This flange, to which the airscrew hub is secured by eight 14 mm bolts with countersunk heads, is mounted on a large single race ball-bearing, 132 mm outside diameter, behind which is fitted the double thrust ball race, 108 mm. diameter on the ball center diameter.

On the front portion of this airscrew hub carrying flange is mounted a double oil thrower ring, which is driven on to the outer diameter of a split collar or bush as shown in Fig 13. The driving gear for the camshafts is machined on this airscrew hub flange, the teeth of the gear are integral with the flange, hence the splitting of the bush which carries the double oil thrower rings.

Airscrew Hub—The general details of the construction of the airscrew hub are given in Fig. 13 Eight 15 mm bolts are used to bolt the front flange to the two rear airscrew hub flanges, and the airscrew is secured by castellated nuts in the usual manner The surface of the airscrew hub and flanges is galvanized with deposited tin to prevent corrosion The front flange floats on the airscrew hub in four castellations, 17 mm wide × 3 mm. deep The total weight of the complete

Fig 16 View of Base Chamber, Showing Oil Pumps

airscrew hub, with all bolts, less extension flange on end of crankshaft = 22 lb

Crank Chamber—The photographs, Figs. 14 and 15, show clearly in perspective the general formation of the cast aluminum base chamber Unlike most of the earlier aero engines, the bottom halves of the crankshaft main bearings are bolted to the top half of the crank chamber These are very deep in section, and are secured to the crank chamber by 18 mm. diameter bolts, which pass through the crank chamber, and are also used to bolt down the cylinders by means of triangular clamps, now almost standard practice. Flanges are machined at the top end of the holding-down bolts, which are let into recesses cut in the top face of the crankcase The front main bearing cap also carries below the intermediate gear pinion for driving the oil pumps as shown in the general arrangement of the engine Cast aluminum covers are bolted to the front and rear ends of the crankcase for enclosing the camshaft driving gears at the front end, and for the magneto and interrupter gears at the rear end of the engine

Base Chamber—The general construction of the lower half of the crank chamber is shown in Fig 16 It presents several points of interesting design, and is of simple construction, weighing 41.32 lb here. At the rear end of the flange, which is bolted to the top half of the crank chamber in the usual way, extended brackets are cast for taking the two magnetos, and, as will be seen in Fig 16, the three gear type oil pumps are situated on seatings cast on the bottom of the inside of the base chamber

The small detachable oil sumps are fixed to flanges cast on the underside of the base, one at each end.

Fig 17. Crankcase Breather

Crankcase Ventilation—As in the Zeppelin-Maybach engines, the efficient ventilation of the crankcase has received careful consideration The design is, in fact, very similar in both types of engine On the induction side of the engine six breathers are fitted; these are constructed of fairly coarse brass wire-gauze baffles mounted in sheet aluminum breathers, which are attached to short steel tubular connecting lugs screwed into the crankcase, and are fixed in position by steel wire clips Details of the construction of these breathers is shown in sketch Fig. 17

On the exhaust side of the engine a peculiar type of ventilator is fitted. This consists of a sheet aluminum manifold, which is connected by six short rubber joints to the crank chamber. The top portion of the ventilator manifold is so made as to form an oil trap for the condensed vapor This consists of an elliptical suction pipe, which leads from the top of the

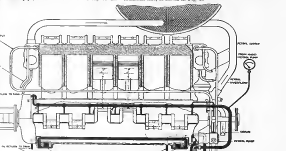


Fig 18. Lubrication Diagram, Also Showing Gasoline System and Water Circulation

chamber formed in the ventilator manifold to a cowl which projects backward from the outside of the engine cowling in the machine.

Lubrication—Several details of the lubrication system have been completely redesigned in the new Maybach engines. The former single oil pump, which was of the plunger type, has

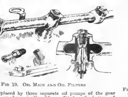


Fig 19. Oil Main and Oil Filters

now been replaced by three separate oil pumps of the gear type. These, as shown in Fig 16, are fitted in the bottom of the base chamber. The main oil pressure pump is at the rear end, while the two scavenger pumps are situated one at each end of the base chamber

The general principle of the lubrication system is here clearly shown in the special diagrammatic drawing, Fig 18, which is to a great extent self-explanatory.

In this diagram the lubrication system is shown with all the oil pipes and oil-ways marked in black The system, briefly described, is as follows —Oil is delivered from the separate oil tank by the pressure oil pump, which is the rearmost pump of the two at the rear of the sump, and forces oil under pressure to the crankshaft journal bearings through an external oil main, which runs the whole length of the crankcase on the induction side, as shown in Fig 19

From this main oil pipe oil is forced to the journal bearings through oil ways drilled diagonally in the crank chamber casting through the transverse webs which support the housings of the journal bearings these are lubricated by a wide helical oil groove cut in the bearing white metal For the lubrication of the crank-pins and the connecting rod small-

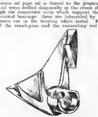


Fig. 20 One of the Oil Scoops Attached to the Sides of the Crank Webs for Conveying Oil to the Crank Pins

end bearings, the well-known Maybach system of centrifugal pressure lubrication is adhered to In this system the oil, which is forced out through the ends of the journal bearings, is collected by the oil scoops, which are bolted to the outer sides of each crank-webs, as shown in the view of the crankshaft (Fig 12).

By centrifugal action the oil is forced up the outer surface of each crank-web and led through a channel into the hollow

crank-pins, thence through a small hole bored radially in each crank pin to the connecting rod big end bearings. From the big end bearings the oil is forced upward to the small end bearings, with their floating gudgeon pin bushes of cast-iron, through the steel pipe fixed in the center of the connecting rods Fig 20 is a detail sketch of one of the aluminum oil scoops, which are bolted in pairs to the crank webs by a bolt which passes through the center of the end crankpin

From the front end of the main oil pipe a steel pipe is connected by a union, which leads to a hole drilled in the crankcase casting, and serves to lubricate the bearings of the camshaft intermediate gears. A restricting plug is fitted into the end of this oil lead, and a similar restriction is provided in the end of the main oil lead back into the crank chamber, as shown in the lubrication diagram.

A check valve, it will be noticed, is fitted in the main oil supply system This check valve, together with a small spring-loaded pressure relief valve, is situated inside a small detachable valve chamber, which is attached to the bottom of the crank chamber just beneath the main oil pump It will be noticed in the lubrication diagram that the excess oil pressure

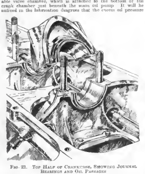


Fig. 21. Top Half of Crankcase, Showing Journal Bearings and Oil Passages

is delivered back into the oil pipe on the supply side of the pump. An oil pressure gage is connected to the main oil lead, as shown, and small oil pipes are also taken from the main pressure pipe to the small crank chamber of the gasoline pump, and also to the water pump driving spindle.

The two scavenger oil pumps, situated one at either end of the base chamber, are designed so as to draw off the return oil which collects in the small detachable oil sumps in the bottom of the oil base, and to return it to the tank from either end.

These scavenger pumps are connected together by a steel pipe, 21 mm. diameter, the ends of which are coupled to the suction ports of the two gear oil pumps. This inter-connection of the two pumps, to a certain extent, balances the oil return to the tank from the front and rear ends of the oil base, enabling both scavenger pumps to operate at any angle of the engine.

A small quantity of oil is always carried in the oil base, as shown in the lubrication diagram The camshafts, tappets and cylinder walls are splash lubricated by the surplus oil thrown off the crankshaft and oil scoops, and the camshaft and magneto gears are lubricated through oil ways cut in the camshaft bearings at either end. Baffle plates are fitted below the cylinders in the recesses machined in the top face of the crank chamber, as shown in Fig 21

Constructional Details of Oil Pump—No provision is made for lubricating the roller bearings of the overhead valve rocker spindles, and no oil holes are made in their brackets for hand lubrication

The general design of all three oil pumps and their delivery is the same. The general construction is clearly shown in the sketch of the front scavenger pump (Fig 22) A pair of pump gears of the usual formation, 30 mm diameter, work in a body casting of cast-iron The top pump gear is of steel,

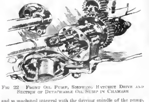


Fig 22 Front Oil Pump, Showing Ratchet Drive and Section of Detachable Oil Sump in Chamber

and is machined integral with the driving spindle of the pump, while the lower pump gear is made of gun-metal The oil pumps are secured to the machined seatings cast on the bottom of the oil base by a stud in each case, which also serves to hold the small detachable oil sumps in position These oil sumps consist of aluminum castings, into the cupped center of which is screwed a spun brass oil trap, formed as shown in the sectional perspective sketch These oil sumps are connected to the suction ports of the oil pumps by a passage formed in the sump body castings

All three oil pumps are driven at the same speed, the two scavenger pumps being connected together by a light tubular shaft, which engages with dog clutches at either end, the pressure oil pump is driven off the spindle of the rear scavenger pump through a dog clutch extension of the spindle.

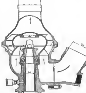


Fig 23 Section of Water Pump

The method of driving the oil pumps at the front end of the engine is of interesting and unusual design As shown in Fig 22, the driving gear wheel, which is mounted on the front extension of the pump spindle, is provided with a spring-loaded face ratchet, the teeth of which are cut inside the gear, as shown, and engage with similar teeth cut on a flange on the front of the pump driving spindle The strength of the spring is such as to allow the driving gear to overrun the driving spindle, and apparently in the event of backfiring all the oil pumps become inoperative, and would thus be prevented from being sucked back into the oil base by the two scavenger pumps.

An interesting feature in the lubrication system of these engines is found in the small separate oil filters, which are provided at the top of each of the diagonal oil ways drilled through the webs of the main journal bearing housings. The small filters are screwed into the bosses, which are cast on the outside of the crank chamber, and to which the detachable main oil pressure pipe is attached

In Fig 19 the method of attaching the main oil pipe by a set screw and a cap fitted with a leather washer is shown The set screw is screwed into the top of the filter plug at the top of the drilled oil lead, and a small jet or drilled plug is fitted below the set screw, the plug being let into a small recess cut in the top of the oil lead.

Further details of the formation of the oil passages drilled through the crankcase to the journal bearings, and also of the construction of the main bearing caps, are given in the sketch Fig 21, which shows the underneath view of the top half of the crank chamber The oil is led round the bearing bolts through circular oil grooves cut in the face of the bearing housings. The small holes drilled in the crankcase above the joints, as shown, communicate with recesses machined around the bolts. These holes are made to prevent the oil from being forced upward out of the engine through the bolt holes in the crank chamber

Details of the construction of the water pump are shown in the sectional drawing, Fig 23 The body of the water pump is attached to the top face of the separate aluminum casting which forms the cover of the magneto driving gears. This gear cover is attached by bolts and studs to the rear end of both the top and bottom halves of the crank chamber As may be seen in the general arrangement drawing of the engine, the water pump spindle is driven through a dog clutch at its lower end by a short vertical spindle running in a bronze bush bearing, this spindle is driven by a bevel gear meshing with the main bevel fixed on the rear end of the crankshaft

The water pump vertical spindle, which is 20 mm in diameter, runs in a bronze bearing, which is lubricated by a screw grease lubricator The top portion of the pump spindle bearing is cupped to form the housing for a thrust ball race, above which is fixed the pump rotor

The pump rotor is a gun-metal casting having six helical vanes 110 mm in diameter The rotor is fixed to the pump spindle on a taper and key, and is locked by a domed nut and locking washer

The lower half of the pump body is an aluminum casting with an inlet passage 54 mm in diameter, to which the diagonal water pipe from the radiator is coupled by a rubber connection The top half of the water pump body, which is a gun-metal casting, is formed with six helical passages leading in a reverse helical direction to the water pump rotor These passages connect with the common vertical outlet passage in the top of the body casting, as shown in Fig 23. The outlet diameter is 50 mm.

The center portion of the top body casting inside the helical passages above the pump rotor is domed and fitted with a screwed plug 38 mm in diameter This plug is drilled with a 3.5 mm hole, evidently to prevent an air-lock Two 3 mm. holes are also drilled in the bottom of the rotor between the vanes for the same purpose. It is noticeable that the steel ball thrust race is working to all intents in the water flow, and must therefore suffer by corrosion

Water Circulation—The circulation of the water-cooling system is clearly set out in the diagrammatic drawing, Fig 18, from which it will be seen that the water pump delivers directly into the bottom of the water jacket which surrounds the body of the rear carbureter As already mentioned, the two carbureters are attached by long studs to the ends of the front and rear cylinders, and the water, after passing through the rear carbureter water jacket in a special passage round the throttle valve, enters the rear cylinder through the two circular water joint flanges. The water passes through the passages cast in each of the six cylinder heads to the front carbureter water jacket, whence the water is forced out through a vertical passage 50 mm diameter through a diagonal pipe leading to the radiator, which is slung above the engine from the center section of the top plane.

According to a French report, this radiator is very efficient. It is of semi-circular shape in front elevation, and is formed of hexagonal, honeycombed tubes, and exceptionally deep in cross section, measuring 22 cm The radius of the semicircle in elevation is approximately 32 cm

The radiator is divided into two separate sections by a vertical baffle plate, as shown in the diagram Fig 18 Water enters the bottom of the left-hand side of the radiator through the pipe leading from the front carbureter, and flows upward through the tubes of the left hand of the radiator to the top portion of the tank, which completely surrounds the radiator. The water passes over the top of the dividing baffle plate, through the right-hand section to the bottom of the radiator, and out at the rear side, which is connected with a 50 mm. pipe to the inlet passage of the water pump.

The front of the radiator is fitted with a blind, which is operated by a cable from the pilot's seat

(To be continued)

Book Reviews

Guynemer, the Ace of Aces By Jacques Mortane. Translated by Clifton H Levy (Moffat, Yard & Co., New York. Price, $1 50 267 pp , 28 ill)

This volume, which appears under the pen of one of the best French aeronautical writers—who was by the way a close friend of the late Ace—will serve as a valuable contribution to the military record of the Allies' great aerial leaders. The greater part of the book is taken up by lively anecdotic narratives of Guynemer's principal combats, which M Mortane has gathered practically on the spot by personal interview, and which are thus still under the spell of action An interesting counterpart to this story is furnished by the transcripts from Guynemer's service log book, the style of which is notable for its extreme laconism

Airmen will be interested to learn that the great French Ace had no particular method for defeating his foe, nor that he originally possessed any particular inclination for the air service, in fact, he chose this arm of the service only because, having been rejected five times as physically unfit, it afforded the best chance for satisfying his will to serve France. This noble sentiment, which was so strongly developed in his rather frail body, explains Guynemer's untiring efforts, both in air fighting and in improving the armament of his machines It is for this reason that the name of Guynemer is revered by his countrymen not only as the one-time banner-bearer of French "Boche-hunters," but also as personifying the spiritual glory of France, "the purest symbol of the qualities of the race"—to quote part of his twenty-sixth and last citation, which now adorns the walls of the Pantheon in Paris.

Automotive Magneto Ignition By Mich. E Toepel, M S. A. E (Spon & Chamberlain, New York Price, $2 Ill)

Although most American aero-engines are fitted with battery ignition, in Europe the magneto reigns supreme, and latterly some magneto-ignited engines have also appeared in this country With a view toward furnishing ready reference on this subject, the author has written a textbook which deals exhaustively with the features of magneto ignition Arranged in the form of queries and answers, this textbook, which is of pocket size, seems to fill a long-felt want, and should prove of value to all whose line of endeavor demands thorough knowledge of this subject matter

Above the Battle By Vivian Drake (D Appleton & Co. $1.50 303 pp)

This book is by far one of the best that have been written by flying officers on the more intimate aspects of military aeronautics. The author, who is a captain of the British Royal Air Force, begins his narrative with the training of an airman from the time of his enlistment up to the moment when he gets the much-coveted "wings." He then proceeds to tell of the work at the front, raid rehearsing, bombing from an airplane, night flying, air photography, the relation of the Air Force to the artillery, the importance of wireless in directing gun fire, etc He gives many remarkable descriptions of air raids over the enemy lines, and tells how it feels to be a target of one of the aces of the German army and get away without a scratch His story is full of exciting incident, yet always plausible, and is told in a delightfully humorous style that makes it irresistible reading

Development of Naval Aeronautics

Congressman Padgett, chairman of the Committee on Naval Affairs, delivered in the House on Oct. 14 a comprehensive address on the accomplishments of the United States Navy, in connection with which he submitted reports prepared by the chiefs of the several bureaus. Excerpts from reports dealing with naval aeronautics are printed herewith.

From the Report of the Office of Naval Operations. Previous to the declaration of war the Navy had maintained but one air station. This was a small but complete and active station at Pensacola, Fla., which was used for instruction and experimental work. The personnel of aviation at this time consisted of about 30 line officers of the Navy, Marine Corps and Coast Guard, who were trained as aviators, and 300 men. The aircraft in use consisted of a variety of American and foreign types which had been purchased by the department. Owing to the limited facilities and small appropriations, the results of these activities were not very extensive.

The Naval Reserve Flying Corps was established by law in 1916, but it was not until February, 1917, that a definite interpretation was placed on this law and that enrollments in the Naval Reserve Flying Corps actually began. The officers who received training in aviation had been regarded as having been detailed for special duty in connection with aviation. The law passed by Congress in 1916 authorizing the Naval Reserve included not only a reserve to be attached to the fleet but the Naval Reserve Flying Corps. Accordingly when war was declared steps were taken to enroll and train a large number of men for ultimate qualification as pilots. In addition, facilities were provided for the training of a large number of men specialized in the various functions pertaining to aviation and at the present time schools are in operation for the training of pilots, mechanics, gas-engine experts, communication officers, etc.

40,383 Officers and Men

On Oct. 2, 1918, the total strength of naval aviation was approximately 40,383 officers and men. Of this number, 16,621 are now abroad and actively engaged in operations against the enemy. This increase in the aviation personnel of the Navy since the beginning of the war has called for an enormous expansion of training facilities. When the training program was first put into operation there was but one ground school. This school provided at that time training facilities for about 300 men. At the present time this number has been increased to 1200, and, in addition, schools have been established in the Central West and near the Pacific Coast. For the training of airship pilots a school was established in Ohio, and the department is now contemplating the establishment of an additional school.

It was evident to naval authorities that one of the most important ways of assisting the allies was to engage immediately in the antisubmarine warfare. In order to bring the United States to the point where the most good could be accomplished with the facilities immediately available, various methods of combating the submarine were carefully considered. As a result, it was decided to establish coastal patrol stations, both in this country and abroad.

Construction of stations in the United States was started immediately, and today practically the entire eastern Atlantic coast is being patrolled by naval aircraft, and the Navy Department is prepared to extend these operations along the Gulf and Pacific coasts. In addition to seaplane-patrol stations, airship and kite-balloon stations have been put into operation, and, in order to attain the greatest possible efficiency and cruising radius for seaplanes, rest and supply stations are being located at the most advantageous points.

The increase in the number of stations abroad has been fully as great. The month following the declaration of war 5 naval aviators and 100 enlisted men were sent abroad, and these forces were the first forces of the United States to land in France for service against the enemy. The bodies of three of these men are now buried in France and two others were killed in seaplane accidents. Since the arrival of this first expedition abroad, stations have been established not only in France, but in England, Ireland and Italy as well. In order to appreciate more fully the magnitude of this achievement, it may be said that it has been necessary to ship from the United States practically all the material for these stations, which includes hangars, machinery, and, in a word, everything that will eventually be used at these points.

Patrols Fly 404,775 Miles

During the month of September, 1918, aircraft engaged in patrol flights in the United States covered a total distance of 404,775 miles. Aircraft engaged in training flights covered a total of 1,317,460 miles during the same period. It is not considered advisable to give out actual figures regarding the operations at foreign stations. The work abroad has gone forward steadily and the results obtained are becoming more and more important. A recent announcement by the Navy Department to the effect that American naval aircraft successfully attacked and destroyed a German submarine, is only one illustration of the work that is being done over there. The stations, in addition to carrying out active antisubmarine patrols, have been engaged in assisting vessels of the fleet in convoying troop and merchant ships.

On April 27, 1918, an American airship abroad made a continuous flight for 25 hours and 43 minutes, during the course of which three convoys were escorted for 13 hours and 50 minutes in a zone which was mined and patrolled. In recognition of this accomplishment the French Minister of the Marine officially complimented the American forces, saying that "such an ascension of 25 hours and 43 minutes, which constitutes by its duration a remarkable performance, gives us proof of the most excellent qualities of endurance, of energy, of sang-froid, and of technical ability of the American forces."

Naval Aircraft in Bombing Raids

In addition to the activities mentioned above, the Navy Department decided to organize an expedition to destroy enemy submarine and naval bases. The personnel and material of this expedition was organized in the United States and later sent abroad. On Aug. 15, 1918, it was announced that operations had been started by bombing and destroying enemy bases in Belgium. The scope of the activities of the expedition have since been increased and the original forces augmented from time to time.

When war was declared on April 6, 1917, 93 heavier than air seaplanes had previously been delivered to the Navy and about 135 were on order. Of the number that had previously been delivered, only 21 were in use, the remainder having been worn out or lost. These seaplanes were of the N 9 and R-6 types, which are now considered as training seaplanes.

After eliminating types which had been tried and found unsuitable, the department fixed upon two sizes for war purposes which had been perfected in the United States in anticipation of the development of a high-powered engine. The engine developed is the Liberty. The flying boat, which, at the present time, is strongly favored, is an American conception and it has not been found necessary to copy foreign patterns to insure our flyers being supplied with the best. With this development of the heavier than-air craft came the development of airships and kite balloons.

900 Seaplanes in Commission

With the development of suitable planes and engines, the Navy was able to select the type of aircraft which was best suited for its service and to frame a large and definite building program. As a result there are now over 500 seaplanes in use at naval air stations in the United States and up to date over 400 seaplanes have been sent abroad. Other aircraft at stations, both in this country and abroad, includes airships and kite balloons. There has been no undue delay in supplying seaplanes and the delivery of service seaplanes is approximately one month ahead of the scheduled time.

The demand for aircraft necessitated an enormous increase of production facilities, and, as a part of this extension, the Navy Department undertook to build and equip a naval aircraft factory at the Philadelphia Navy Yard. Within 90 days from the date the land had been assigned, the factory was erected and the keel of the first flying boat was laid down. In August, 1918, this factory was producing 50 per cent more seaplanes than it had been two months previous. In addition, at least five plants are at present devoted to Navy work and a large proportion of the output of several other factories has been assigned to the Navy.

The delivery of seaplanes for training purposes has been sufficient to more than meet the requirements. The training of personnel and providing of stations and equipment to carry out this training has expanded sufficiently so that the present output of pilots, observers, mechanicians, and men trained in special branches, is keeping abreast or ahead of requirements.

The confidential nature of the work prevents any definite statement being made as to future operations. However, it may be said that the Navy Department recently established several air stations in Canada. These stations have been supplied with personnel and material from the United States, and the Navy Department is at present engaged in training personnel for the Canadian Government, which personnel will eventually take over the operation of the stations. In addition, the government of our allies have requested the Navy Department to take over more stations abroad, and not only are they desired to continue present operations, but also to increase the field of their activities.

From the Report of the Bureau of Steam Engineering. The marked military advantage to be gained by having but one type of airplane engine prompted the Navy Department to adopt the engine used by the Army. All Liberty engines used by the Navy are, therefore, obtained through the Aircraft Production Board.

1500 Liberty Engines

About 1500 of these engines have been delivered and have been assigned to naval air stations in this country and abroad. Since the number of Liberty engines produced has been too small for the needs of the Army alone, it has been necessary for the Navy to purchase others, to the number of about 700, which have been utilized while awaiting a full supply of Liberty engines.

In addition to these, a large number of engines of less power have been bought for use in training planes, all of which have been distributed to the flying schools, the most important of which is at Pensacola, Fla.

One of the very important duties devolving on the Bureau of Steam Engineering is the equipment and maintenance of stations for the generation of hydrogen for use in airships. A number of stations have been established and a full equipment of hydrogen cylinders provided, so that any calls may be promptly met.

It has also been necessary to give suitable training to a number of young officers for this work and to assign them to stations at home and abroad for the proper conduct of these plants.

Naval Aircraft Factory

From the Report of the Bureau of Construction and Repair. The department has designed, built and equipped at the Navy Yard, Philadelphia, a factory for producing naval aircraft. This factory has been delivering planes since April of the present year. In January last it was decided to quadruple the capacity of the naval aircraft factory. The expansion is now nearing completion, and the present capacity of the aircraft factory is about fifty seaplanes of the largest size per month, and will, it is expected, eventually reach a capacity of ninety-five seaplanes of the largest size per month.

Construction of Air Stations

From the Report of the Bureau of Yards and Docks. On the outbreak of the war the only air station in operation in this country was the one at Pensacola, Fla. Immediately upon the declaration of hostilities plans for new stations were drawn, and in May of 1917 actual construction started. Since that time eleven large additional stations have been put in operation, and also a number of strategic points to assist in efficient patrol work. These stations, including additional work recently authorized and now under way, involve the expenditure of $15,000,000 and provide accommodations for upward of 9000 men and 400 officers. In addition thereto work is just started at the site of the new station on the Gulf, the initial cost of which will run to $1,200,000, providing for 600 men and 70 officers.

Kite-balloon stations are being provided, one each in the first, third and sixth naval districts and two in the fifth naval district, involving an expenditure of $500,000.

The bureau is as well supplying plans, hangars and portable buildings for construction by the Canadian Government.

Development of Aircraft Ordnance

From the Report of the Ordnance Bureau. As the seaplane is an important means for attacking the submarine, special attention has been given to the development of aircraft devices. The past year has brought the perfection of the non-recoil gun and the Lewis gun has been adapted to seaplane use.

Aircraft bombs designed to explode either on impact, if they hit a submarine, or at a predetermined depth, like the ordinary depth charge, have been developed, and the required quantities are being made. Sights for their accurate aim and improved seaplane cameras have accompanied them.

Armaments for airships and seaplanes was given early attention and bombs of various types together with necessary machine guns, etc., were placed in manufacture and have met the demands of the service. New and improved depth bombs have given much satisfaction. Various training devices for bomb dropping and gunners have been supplied.

For Comfort in Flying

To those who recall the early, "heroic" days of aviation, when the pilot would sit on a hard board or on crossed leather straps, amidst a maze of wires, the modern airplane, with its comfortable and unobstructed cockpit, appears to be the acme of perfection. Indeed, hardly a day passes but some accessory is brought on the market with a view to improving the comfort of the pilot and thus reducing the strain of flying.

One such accessory, the Warner Knee Control, which is illustrated herewith, has recently given a convincing demonstration of its practical value. Postal Airman Robert F. Shank had the mail planes he flies on the New York-Philadelphia-Washington route equipped with this "gadget," and has derived considerable satisfaction from it, because, he says, "it allows me the free use of both hands, and as schedule leaving time is noon every day, I now take my lunch with me and eat it while en route."

A distinct advantage of the Warner control may be found in that the knee grip, which is shaped to the contour of the legs, is adjustable in flight to fit any size pilot. Control of the machine with the legs thus is a positive function, the more so as the knee grip is ribbed vertically to prevent forward or backward slipping. The knee grip will be found particularly desirable on cross-country trips involving several hours of flying.

Powerful Airplane Flare

An airplane flare with a brilliancy equalling that of 400,000 candles has been perfected by the Ordnance Department of the War Department. When hanging from its parachute over a German munition plant it lights up an area so brightly that an airman thousands of feet in the air can select any building he is directed to make a target for his aerial bomb, and, it may be added, American aviators are becoming so expert in bombing that they can usually hit the target at which they aim.

In every European city within the zone of aerial raiding operations the rule is rigidly enforced against the burning of lights in any building that might possibly be used as a target. Having reached the particular district sought, he must locate the particular object of his attack from his position, which may be 5000 or 10,000 ft., or even higher, above the earth. Equipped with the airplane flare, the aviator pulls a lever and releases it. As it drops, the resistance offered by the air sets the fuse mechanism in operation. The result is the emission of a powerful light of from 300,000 to 400,000 candle power which completely illuminates the terrain below. The amount of light given is equal to that of a battery of from 150 to 175 street arc lamps, or of from 15,000 to 17,500 ordinary incandescent lamp bulbs such as are used home

Digest of the Foreign Aeronautical Press

***Aeronautics*, Sept. 18, 1918**

The Common Round—The following incidents, drawn from the battle zone records of the Royal Air Force, are but specimens which illustrate the nature of the day's work of airmen in France

A two-seater machine was engaged in special work when it was attacked by seven German machines, which surrounded it, firing at the British machine from all sides. The Germans used explosive bullets. Fighting gallantly against these crushing odds, the British pilot battled his way through the enemy formation. In the course of the fight, however, one of his legs was hit five times, so that the limb was all but severed, and fell among the controls. By a supreme effort the pilot clung grimly to consciousness, and somehow managed to disentangle his leg from the controls. Not only so, but he succeeded in landing the machine safely behind the British lines.

Another two-seater machine, while escorting a bombing formation, sighted 20 German fighting planes. The pilot instantly dived to the attack and selected his first victim. He closed, and, putting in a burst of machine-gun fire at a distance of only a few feet, saw the German pilot go down in flames. Alarmed by the suddenness of his attack, the other Germans had scattered somewhat, and the Englishman was able to dive on another. Just as he came within range, however, his gun jammed, and at the same moment several Germans attacked his machine from the rear. His observer now came into the running, and, opening fire, sent one of the following enemy machines spinning earthward. Having cleared the jam, the pilot, maneuvering at great speed, succeeded in getting a third Hun across his front, where he opened fire at short range and sent his opponent whirling down, a burning mass.

The same day a highly successful raid was carried out on a German aerodrome by combined British and American squadrons. Successive formations, flying very low, released their bombs on hangars, machines on the ground, and hutments. By this bombardment the German petrol and oil store was set on fire, which, in turn, spread to the ammunition dump. Six machines on the ground were destroyed by fire, and two more by direct hits, two large Gotha and several smaller hangars were enveloped in flames, as well as some living huts of the personnel of the German squadrons. The Germans rushed out and desperately endeavored to put out the flames, whereupon the leading planes immediately swooped down again to the attack, and plied the Germans with machine-gun fire, scattering panic-stricken mechanics in all directions, and laying low many of them. Meanwhile, a supporting squadron of British machines unloaded their bombs on to a chateau used as officers' quarters, and completely destroyed it. In spite of the exceedingly heavy ground fire to which the attackers were subjected, every machine engaged returned safely

Shortly afterward a large scale raid was carried out by British and Australian squadrons upon another German aerodrome, where—again from a very low height, to insure greater accuracy—a shower of bombs was released, as a result of which three large hangars containing machines were completely burned out and others badly damaged. The German pilots' mess was blown up, and several fires were started among the mechanics' huts. The airmen next turned their attention to a neighboring station where German troops were entraining. Coming down in some cases to a bare 50 ft. from the ground, the raiders opened fire with their machine guns, and did tremendous execution among the German soldiers crowded on the platforms. German staff officers superintending the entrainment rushed to their waiting cars and attempted to escape, only to be pursued remorselessly. The drivers were apparently hit, for one car upset in a ditch, while the other ran up a steep bank and overturned. In this case again every machine engaged in the raid returned safely.

Work of the French Air Service—The French do not make a practice, as we do, of advertising their aircraft losses side by side with their victories. Of the latter we are well aware from the daily bulletins, but as the French losses are not quoted it has been generally thought that their victories have been gained at a disproportionate cost. We are glad, therefore, to be in a position to dispel this illusion. The following figures relating to the work of the French Air Service are authoritative. They date from the opening of the big German offensive on March 21. Enemy airplanes destroyed or sent down out of control

March (21 to 31)	80
April	126
May	340
June	331
July	285
August (1 to 15)	163
Total	1,325

Enemy kite balloons destroyed during this period are as follows

March (21 to 31)	8
April	11
May	20
June	31
July	39
August (1 to 15)	29
Total	147

Let us turn to the French bombing squadrons. Their record follows

	By Day Tons	By Night Tons
March (21 to 31)	29	50
April	106	112
May	156	373
June	213	428
July	194	350
August (1 to 15)	80	204
Total	778	1,523

Against this aggregate we have to list the number of French machines lost. Those crashed within the French lines by enemy action number

March (21 to 31)	8
April	10
May	14
June	24
July	25
August (1 to 15)	13
Total	94

But this is not all. There remain those machines which, venturing far behind the lines, are dryly catalogued as "missing." So far as the French are concerned, the figures relating to these are given in the following column. It should be remembered that many airmen posted as "missing" are alive and prisoners of war

March (21 to 31)	22
April	29
May	46
June	64
July	67
August (1 to 15)	26
Total	254

The total losses of the French in aerial fighting have therefore been, from March 21 to August 15, 348. During the same period they have destroyed, or sent down out of control, 1,325 planes, and brought down in flames 147 observation balloons, so that their balance appears to be well on the right side.

***Flying* (London), Oct. 2, 1918**

Commercial Aviation—Speaking on the subject of post war development on Sept 23, Lord Montagu expressed a belief in the possibility of a silent airplane engine as an aid to passenger air services of the future. Mr Handley Page afterward spoke on the subject of post-war developments. He expressed the opinion that a passenger service, charging little more than first-class rail fares between the places it served, could show a profit of 98½ per cent on invested capital as long as it ran full cars every time, and in the course of his address he introduced a number of very interesting lantern slides of the London-Constantinople flight, and of bombing machines in the war area.

News of the Fortnight

General Kenly on the DH-4

The War Department authorizes the following statement by Major-General Wm L. Kenly

"A captain of the Air Service, recently arrived from France, has reported to me that the first de Haviland 4 planes with Liberty engines arrived from the U S A at stations in France as early as May 13, 1918, and since that date have been coming in ever-increasing quantities. This officer left the assembling station in France on Aug 20 He said that it had been necessary to make some changes on the first planes received, but that each succeeding shipment evidenced better care, and, in general, when he left these airplanes were very satisfactory

"In his report he also said 'The performance of the planes was very good and the plane and motor has become very popular with our pilots. We obtained approximately 130 miles per hour at ground levels with one plane, and had without any special preparation obtained an altitude of 10,000 ft. in 10 min and 21 sec, full load, excepting bombs. We were able to loop, dive and otherwise stunt these planes exactly as well as we would any chasse plane

"'When I left the post the planes were arriving at the rate of 15 to 18 per day. The cars were unloaded by our steam crane, and fuselages unpacked in one bay (platform), wings in another bay, and assembly was progressing, similar to the method used in automobile construction.

"'After gun test, engine test and final assembly, the compasses were tested and corrected for permanent magnetism The machines were then sent to the flying field and were given test flights After final approval they were then dispatched to stations for assignment to squadron

"'Air-test pilots and ferry pilots were all of the opinion that the plane was excellent The French ministry thought so well of the Liberty engine that the Under Secretary of State for Aviation, M. Dumesnil, informed me that the French would gladly take every engine we could produce which we could not use ourselves I was also given the same information by Captain de Haviland, the designer of the de Haviland plane.

"'Lieut-Col Warwick Wright, R A F, stated to me that the method of packing the plane was considered by the British to be so good that it could not be improved upon Out of 750 cases which I inspected, I only discovered one in which the contents were badly damaged'"

A record for flight between Washington and the field at Mineola L I was established on Sept. 25 by Major-Gen. William L Kenly, Director of Military Aeronautics, and Col C K Rhinehardt in a Liberty DH4, which beat the old record of 2 hours and 12 minutes by nine minutes Also in the severest test to which it has so far been subjected, the Liberty engine responded to every demand made upon it. The exploit caused great satisfaction to the chiefs of the Air Service Major-General Kenly said that the engine is everything that has been hoped for it, "and just a little bit more."

Frederick E Randall Dead

Frederick E Randall, well-known in the automobile trade about Boston, died last week at his home in Roxbury after a two weeks' illness of pneumonia, following an attack of influenza Randall, who had been in local automobile circles since the pioneer days, had sacrificed his business at the time of the first draft, intending to go into the service Disqualified physically, however, he entered the employ of the Wright-Martin Aircraft Corp, and was placed in charge of the Long Island City plant He was 28 years old and leaves a widow

Anderson Heads Aircraft Publicity

Lee Anderson, vice-president and sales manager of the Hupp Motor Car Corp, of Detroit, has been put in charge of publicity for the Aircraft Production Bureau in Detroit. Means to stimulate production are planned and worked out in this office.

Doolittle Joins Aircraft Bureau

A. H. Doolittle, formerly sales and advertising manager of the Zenith Carburetor Co, of Detroit, has joined the Publication Division, Service Department, Bureau of Aircraft, Detroit He was at one time connected with the Knox and the Continental Motors Co.

Maine Spruce Is in Demand

President James Q Gulnac, of Bangor (Me) Chamber of Commerce, W H. Cutler, secretary of the Eastern Lumbermen's Association, Hall C Dearborn, Examiner for the United States Employment Service, recently conferred in Boston, Mass, with other Maine men, including Hon C S. Hichborn, of Augusta, Me., Director for the United States Employment Service, on matters connected with employes for the lumbering industry in Maine.

Maine spruce has been discovered to be of prime importance in airplane construction.

In order to get the quantity desired, it will be necessary for the lumber operators of Maine to make an advance selection of their stands of timber, cutting where the quality of the spruce is best, and cutting a maximum quantity as the percentage of good airplane stock even under perfect conditions is not large. Lumbermen in Maine, who do not have other war work to do through the winter months, will be asked to assist in this program as laborers, but that supply will be insufficient.

Offices have been established in Boston by the Government for the recruiting of wood labor and transfer arrangement has been made for getting these men into Maine. Only one employment service can be used, as a complete record must be kept and furnished daily to the Maine, Massachusetts and the War Airplane Department authorities.

It is a well known fact that there are other direct war industries using the product of the Maine forests, and all of these departments of the industry will receive proper protection and consideration under the present plans.

New Airplane Testing Methods

By an agreement between the two divisions of the Air Service, the acceptance parks or testing fields located at Dayton, Ohio; Detroit, Mich Buffalo, N Y, and Elizabeth, N J., have been transferred from the jurisdiction of the Bureau of Aircraft Production to the Division of Military Aeronautics, and the method of testing the finished product is now undergoing a complete change

Instead of flying each machine produced at least one hour before crating, as has been the practice, the fifteenth, twentieth or thirtieth plane, as may be decided, will be picked from the shop run, shipped direct to a testing squadron and given a try-out, or, to use the technical expression, "flown to destruction" The other planes will be immediately crated and sent on the way As fast as the testing squadron develops a weakness in any machine the fault found will be flashed both to the factory and overseas and remedied before the plane takes the air.

Thus, with the factory inspection of parts and assembling maintained at a high mark and the flying tests stiffened, efficiency and accuracy of production has been increased, and at the same time there has been a further reduction of time lost in the flow of engines and airplanes overseas

Importation of Balsa Wood

The War Trade Board has by a new ruling (No 273) placed restrictions upon the importation of balsa wood, including ceiba wood and other light woods usually designated as balsa wood.

All outstanding licenses have been revoked as to ocean shipment from abroad after Oct 10, 1918, and no further licenses will be issued, except to cover shipments made from abroad on or before Oct 10, 1918, shipments from Canada or Mexico by other than ocean transportation, shipments from Europe or Mediterranean Africa when coming as return cargo from convenient ports where loading can be done without delay, and shipments not covered by the above provisions to a total of not to exceed 1,600,000 board feet

The amount permitted to come forward will be allocated by the Bureau of Imports.

May Move Aircraft Production Section

Washington reports state that the Aircraft Production Section of the Army has under consideration a plan to move its whole office force to New York and to make that city its headquarters instead of Washington.

L. W. F. Engineering Banquet

The Engineering Department of the L. W. F. Engineering Company of College Point, N. Y., held an "old timers' dinner" at the Hotel McAlpin, New York, on Saturday, Oct. 19. The event served as a get-together gathering and as a farewell token of esteem to Archibald Black, the company's chief aeronautical engineer, who has severed his connection with the L.W.F. organization to take up work under Naval Constructor J. C. Hunsaker in the Department of Construction and Repair, Navy Department, Washington, D. C.

Archibald Black

The table was attractively decorated, and at each place was a four page menu rendered in blue print in true engineering style. On the first page was a picture of the first machine fitted with the Liberty engine, while inside was the list of the guests and the "Bill of Material." The last page showed a draftsman doing his best to keep up with the changes, with discarded sheets thrown on the floor and in the scrap basket, representing former engineering department members who had entered various branches of the service.

The souvenirs at each place consisted of test sections of the wing beams of the first airplane that flew a Liberty motor.

Archibald Black acted as toastmaster, and in an interesting address he told of the accomplishments of the L. W. F. Engineering Department during his connection with the company. He introduced the following speakers: Herbert M. Williams, who spoke on the future of aviation; Glenn D. Mitchell, who told of the detailed history of the L. W. F. organization; H. Zuege, who described production troubles and how they were overcome; Alfred Reppuhn, who described the experimental work at Mineola, and H. H. Nordman, who gave some entertaining reminiscences of early aeronautics.

Among those present were: G. D. Mitchell, Mechanical Engineer; A. Black, Aeronautical Engineer; E. J. Secco, Test Mechanic; H. J. Orgass, Foreman B. M.; H. J. Nordman, Foreman H. S. 2 L.; L. W. Bettiger, Chief Draftsman; J. L. Harkness, Test Engineer; J. E. Connaughton, Foreman; F. E. David, Checker; J. J. McCafferty, Plant Layout Draftsman; P. Rhinelander, Assistant to General Superintendent; H. Zuege, Production Manager; D. Wells, Assistant Production Manager; F. J. Bostwick, Planning Supervisor; Alfred Reppuhn, Engineer Boyce Motometer Company; H. M. Williams, of Aviation and Aeronautical Engineering.

After the addresses the guests sang patriotic and popular songs, and a rousing send-off was given to Mr. Black.

Archibald Black was born in Scotland thirty years ago. After some years in the electrical line there he came to America, just at the time when flying was in its infancy. His interest in aviation dates back a decade, and the optimism he has held for its future during these years has spurred him on to study and keep in close touch with the business.

After coming to this country, Mr. Black remained in his old line, being engaged in electric power plant engineering for the New York Edison Co., Detroit Edison Co., Union Metallic Cartridge, and other concerns. Early in 1916 he took a position in the Engineering Department of the Curtiss Aeroplane Co. in Buffalo, where he remained until joining the L.W.F. Engineering Co. in August, 1916. Various L.W.F. machines have been built under Mr. Black's direction, noteworthy among which was Model F, which was the first airplane fitted with a Liberty engine to fly successfully.

Furloughs for War Workers

The War Industries Board authorizes the following:

Following the announcement by Bernard M. Baruch, chairman of the War Industries Board, that there would be cooperation by the War Industries Board and the War Department in determining furloughs from military service of skilled laborers and others engaged in important war work, the War Industries Board has appointed William M. Ritter, of West Virginia, who is assistant to George N. Peek, commissioner of finished products, as certifying officer representing the board in this vital work.

Mr. Ritter will be the point of contact between the War Industries Board and Darragh de Lancey, of the industrial furlough section of the Adjutant General's Office in the War Department, through whom decision will be made as to the essentiality of certain men in war industry and necessity for their furlough from military service although called in the selective draft.

All requests for the furlough of men made by the various departments of the War Industries Board will be made through Mr. Ritter, who will make such investigation in each case as in his judgment the circumstances warrant to determine whether the requests are justified.

Heads of industries in war work who find that the draft is taking from them such of their skilled men as to impair efficiency and seriously reduce production of war material are expected to apply to the War Industries Board for the furlough of these essential skilled men. Commodity section chiefs in the board, handling matters in connection with the industry alleged to be affected by the draft, will make investigations as to the needs and conditions before acting on the requests for furloughs coming to them, and will then report to Mr. Ritter.

Men furloughed from military service on the recommendations of Mr. Ritter as certifying officer for the War Industries Board, will be instructed to report to the industry applying for their furlough and that industry will be required to make regular monthly reports to the certifying officer showing the continuance of the furloughed men in their employ. Change of place of employment or of character of work will lead to revocation of the furlough order, and return of such men to or into the military service.

French Optical Glass Importation

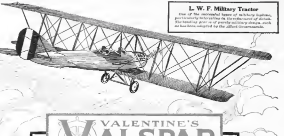
Hereafter orders for the importation of French optical glass into the United States must be placed through the War Industries Board and the War Trade Board. Direct orders for importation will not be allowed.

The regulations provide: 1. All import orders for French optical glass should be placed with the Service Geographique, which will distribute them among the various French manufacturers. 2. The order, together with the application for import license, should be forwarded to the War Trade Board, Bureau of Imports, to the attention of Mr. Reardon. 3. The applications should state in detail the purpose for which the glass is intended. 4. The War Trade Board will in all cases consult with the Military Optical Glass Section of the War Industries Board before applications are granted. 5. Orders placed direct will not have the approval of the Military Optical Glass Section nor the necessary endorsement of the War Trade Board to allow the glass to be imported from France. 6. If glass of a special manufacturer is desired, it may be noted on the order.

Hartzell Propeller Company Opens New Office

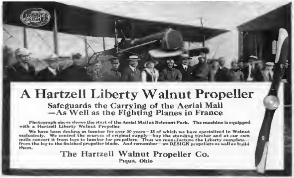
The Hartzell Propeller Company of Piqua, Ohio, wishes to announce that Harry B. Wise, Sales Manager, has opened an office in the Mutual Home Building, Dayton, Ohio, to facilitate Middle West business, and the Hartzell Company will be glad to have its many friends call upon Mr. Wise whenever convenient.

Speaking of Hartzell production, it was said in our issue of August 15, 1918, that Liberty airscrews were turned out at Piqua "in numbers which it would comfort the enemy to know." As this wording appears to have been misconstrued by some of our readers, it seems necessary to point out that, since the publication of confidential information on war material gives aid and comfort to the enemy, the sentence obviously implied that Hartzell production was running into such high figures that it had to be kept secret in the interest of the prosecution of the war.



L. W. F. Military Tractor

One of the successful types of military biplane, particularly interesting in its refinement of detail. The landing gear is of purely military design, such as has been adopted by the Allied Governments.


LIBERTY

Aeronautical Trade Directory

AVIATION AND AERONAUTICAL ENGINEERING will furnish information and addresses of companies listed below

Names of Advertisers in this issue are printed in capitals

See Index to Advertisers on page 461

ACCESSORIES AND INSTRUMENTS

Advance Felt Specialty & Cutting Co
International Aeronautical Instrument Corp.
Johns Manville H. W. Co
King, Julius, Optical Co.
The Moto Meter Co
National Gauge & Equipment Co
Nelson Blower & Furnace Co.
O'Hara Waltham Dial Co.
Queen Gray Co.
Ricker Walton
SPERRY GYROSCOPE CO
Standard Aeronautical Co
Stewart Warner Speedometer Corp.
TAYLOR INSTRUMENT COMPANIES
VEEDER MFG CO
Western Electric Co.

AIRPLANES

Aeromarine Plane and Motor Co.
Blackhawk Airplane Co
Blanchard Radley Aircraft Co.
Boeing Airplane Co
Breese Aircraft Corp.
THE BURGESS COMPANY
California Aviation Co.
Continental Aircraft Corp.
CURTISS AEROPLANE & MOTOR CORP
DAYTON WRIGHT AIRPLANE CO
Des Lauriers Aircraft Corp.
Dewey Aeroplane Co.
Engel Aircraft Co.
Fisher Body Corp.
Fowler Airplane Corp.
Gallaudet Aircraft Corp
Lanzius Aircraft Co
Lawrence-Lewis Aeroplane Co.
Lawson Aircraft Corp.
Lewis & Vought Corp.
Liberty Iron Works
Loening Aeronautical Eng. Corp
Longren Aeroplane Co.
L. W. F. ENGINEERING CO
Martin Aeroplane Factory
MARTIN, GLENN L., CO.
Michigan Aircraft Corp.
Ordnance Eng'ring Corp.
Patterson Aeroplane Co
Peirce Sam'l S., Aeroplane Corp.
RUBAY CO
St. Louis Aircraft Co.
Smith, Kyle, Aircraft Co.
Sperry Lawrence, Aircraft Co.
Springfield Airplane Co
STANDARD AIRCRAFT CORP
STURTEVANT AEROPLANE CO
THOMAS-MORSE AIRCRAFT CORP
The Willys-Morrow Co.
WITTEMANN-LEWIS AIRCRAFT CO
Whittemore-Hamm Co.
WRIGHT MARTIN AIRCRAFT CORP

AIRPLANE ENGINES

Aeromarine Plane and Motor Co.
Ashmusen Mfg. Co.
Continental Motors Co.
CURTISS AEROPLANE & MOTOR CORP
Detroit Gas Turbine Corp.
DUESENBERG MOTOR CORP
General Ordnance Co.
General Vehicle Co.
Gyro Motor Co.
HALL-SCOTT MOTOR CAR CO
Kemp Machine Works.
Kessler Motor Co
Knox Motors Co.
Nordyke & Marmon.
Packard Motor Co.
Roberts Motor Mfg. Co
Rolls-Royce, Ltd.
Springfield Motors Co
Sterling Engine Co
STURTEVANT, B. F., Co
Trego Motors Corp
THOMAS - MORSE AIRCRAFT CORP
UNION GAS ENGINE CO.
Van Blerck Motor Co
Willys-Overland Co.
WISCONSIN MOTOR MFG CO
Wolds Motor Co.
WRIGHT MARTIN AIRCRAFT CORP

AIRPLANE PARTS

Aircraft Parts Mfg. Co.
American Body Co.
Astoria Veneer Mill & Dock Co
BARCALO MFG CO.
Century Telephone Construction Co
Chicago Aeronautical Supply Co.
Dayton Metal Products Co.
ERIE SPECIALTY CO
General Aluminum & Brass Mfg. Co.
GENERAL BAKELITE CO.
Holbrook Co
KAWNEER MFG CO.
Levett, Walker M., Co.
New Jersey Veneer Co
Pressed & Welded Steel Products Co.
Rogers Construction Co.
Standard Parts Co
Welch Mfg Co
Whittemore-Hamm Co.
WIDMAN, J. C., & CO.
Willys-Morrow Co.
Wilson Cabinet Co.

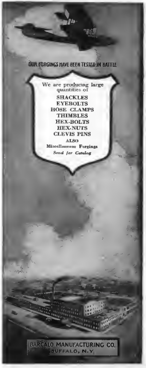
ALUMINUM

Acfreel Co of America
ALUMINUM CASTINGS CO
ALUMINUM CO. OF AMERICA
American Metal Co., Ltd.
General Aluminum & Brass Mfg. Co.
Levett, Walker M., Co.
Leygraud & Co.
McAdamite-Aluminum Co.
So-Luminum Mfg & Eng. Co (Solder)
STIMPSON, EDWIN B., CO
United Smelting & Aluminum Co.

AVIATION SCHOOLS

EAGLE AVIATION SCHOOL
Michigan State Auto School
Morris Bud Airplane School
Penn. State School of Aero-Mechanics
West Side Y. M. C. A
Whittemore-Hamm Co.

(Continued on page 449)



Aeronautical Trade Directory—*Continued*

BALL BEARINGS
The Fafnir Bearing Co.
GURNEY BALL BEARING CO
Hess-Bright Mfg. Co.
NEW DEPARTURE MFG CO.
Norma Company of America
S K F Ball Bearing Co.
U S. Ball Bearing Mfg. Co.

BALLOONS: DIRIGIBLES
Burdett Oxygen Co.
Connecticut Aircraft Co.
Custer Specialty Co. (Statoscope)
Gas Engineering Co. (Gas Plants)
GOODYEAR TIRE AND RUBBER CO
United States Rubber Co.

BAROGRAPHS AND BAROMETERS
Green, Henry J
International Aeronautical Instrument Corp
Spanfield & Lerch
TAYLOR INSTRUMENT COMPANIES

BEARING METALS
Aluminum Castings Co.
AMERICAN BRONZE CORP.
FAHRIG METAL CO
General Aluminum & Brass Mfg. Co
Levett, Walker M., Co.
Magnolia Metal Co.

BUSHINGS
Aluminum Castings Co.
AMERICAN BRONZE CORP.
Bound Brook Oil-less Bearing Co.

CARBURETORS
H. & N. Mfg. Co.
Master Carburetor Co.
Miller Carburetor Co.
Stromberg Motor Devices Co.
Wheeler & Schebler
ZENITH CARBURETOR CO.

CLOCKS AND WATCHES
Chelsea Clock Co.
DEPOLLIER J. & SON
Hamilton Watch Co
Ingersoll, Robert H., & Bros.
Waltham Watch Co

CLOTHING
Abercrombie & Fitch
Cross, Mark
N Y Sporting Goods Co.
Rainwear Co.
Rogers, Peet & Co.
Sanders Company
Spalding, A. G., & Bros

COMPASSES
SPERRY GYROSCOPE CO.
Star Compass Co
TAYLOR INSTRUMENT COMPANIES

DOPE AND VARNISH
Adams & Elting Co.
American Emaillite Co.
BROOKLYN VARNISH MFG CO
Certus Cold Glue Co
Chemical Products Co.
Conover, The C. E. Co.
DU PONT CHEMICAL WORKS
Flexible Compound Co.
Harland, Wm., & Son
Howe Varnish Co.
Lucas, John, Company
Masury, John W. & Son
Perry Austen Company
PRATT & LAMBERT
Sherwin Williams Co
Smith, Edward, & Co.
Standard Varnish Works
VALENTINE & COMPANY
Weeks & Co.

DRIFT INDICATOR
SPERRY GYROSCOPE CO

DRY KILNS
Cutler Dry Kiln Co.
Drying Systems, Inc.
Grand Rapids Veneer Works

DYNAMOMETER
Sprague Electric Works

ENGINE PARTS
Allegheny Forging Co.
Aluminum Castings Co
Anderson Forge & Machine Co.
BARCALO MFG CO.
Brooks Machine Co
Burd High Compression Ring Co.
Crosby Steam Gage & Valve Co.
Dallet, Thos. H. Co
DOEHLER DIE CASTING CO
EBIB SPECIALTY CO.
Fibre Finishing Co.
General Aluminum & Brass Mfg Co.
Gifford, Leland, Co
Gill P. H., & Sons
Hayes Mfg. Co.
Hydraulic Pressed Steel Co.
Levett, Walker M., Co.
Meisel Press Mfg. Co.
PARK DROP FORGE CO
Pressed & Welded Steel Products Co
Standard Parts Co
STIMPSON EDWIN B. CO.
Taft Peirce Mfg. Co.
Tioga Steel & Iron Co.
Williams, J. H., & Co.
Whitman & Barnes Mfg. Co.
WYMAN GORDON CO

ENGINEERING
AUTOMOTIVE ENGINEERING CO
Ordnance Engineering Co.
White, J. G., Engineering Corp.

FABRICS
Courtrai Mfg. Co.
Hutchinson, Scott Co.
Lamb, Finlay & Co.
McBratney, Robt., & Co.
Whitman, Clarence & Co.

FELT
Advance Felt Specialty & Cutting Co.
Booth Felt Co
Western Felt Works

FIRE EXTINGUISHERS
Fyr-Fyter Co.
JOHNS-MANVILLE, H. W., Co.
Pyrene Mfg. Co.

GAGES
Advance Felt Specialty & Cutting Co
BOSTON AUTO GAUGE CO.
Crosby Steam Gauge & Valve Co.
FOXBORO CO., INC.
Greenfield Tap & Die Corp.
United States Gage Co.

GASKETS
Advance Felt Specialty & Cutting Co
Booth Felt Co
Fibre Finishing Co.

GLUE
Armour Glue Works
Baeder & Adamson
Certus Cold Glue Co
Ferdinand, L. W. & Co
Widman J. C. Co

(*Continued on page 451*)

Aeronautical Trade Directory—*Continued*

GOGGLES

HARDY, F. A. CO
Meyrowitz, E. B.
STRAUSS & BUEGELEISEN
Strong, Kennard & Nutt
Triplex Safety Glass Corp.
Willson, T. A., & Co., Inc.

HANGARS

American Bridge Co.
Anchor Corrugating Construction Co.
Ashley Steel Bldg. Co.
Austin Co., The
Barney, John M.
Howell, Field & Goddard, Inc.
Keasby & Mattison
Milliken Brothers
Preden, The C. D., Co.
Steel Fabricating Co., The
Virginia Bridge & Iron Co.

HOISTS

YALE & TOWNE MFG. CO

IGNITION

Philips-Brinton Co., The

LIFE PRESERVERS

Robinson-Roders Co.
Universal Safety Mattress Co

LUMBER

Alcock Co., John L.
American Bales Corp.
Astoria Veneer Mills & Dock Co.
Chetham Lumber Co.
Dolateur, J
Dutton, A. C., Lumber Corp.
Ludlow, Israel
Mengel, C. C., & Bros. Co.
New Jersey Veneer Co.
Sheip & Vandergrift

LUMINOUS COMPOUND

COLD LIGHT MFG. CO.
Cummings, W. L., Chemical Co.
RADIUM DIAL CO.
RADIUM LUMINOUS MATERIAL CORP.

MACHINERY, METAL WORKING

DALTON MFG. CORP.
DEFIANCE MACHINE WORKS
FOX MACHINE CO.
Warner & Swasey Co.

MACHINERY, WOOD-WORKING

Curtis Machine Corp.
DEFIANCE MACHINE WORKS
Fay, J. A., & Egan Co
FOX MACHINE CO.
Machinery Merchants, Inc
MATTISON, C., MACHINE WORKS
Olney & Warrin
Frybill, P. Machine Co.
YATES, P. B., MACHINE CO

MAGNETOS

Berkshire Magneto Corp.
Bosch Magneto Co.
ERICSSON MFG. CO
Remy Electric Co.
Splitdorf Electrical Co.

MANIFOLDS

AJAX AUTO & AERO SHEET METAL CO.
Pressed & Welded Steel Products Co

METALS

Acheson Co. of America
AMERICAN BRONZE CORP
American Vanadium Co.
Bethlehem Steel Co.
Brix Pierce Co., The
BLUM, JULIUS & CO.
Detroit Pressed Steel Co.
Federal Pressed Steel Co.
Garland Ventilator Co.
Gaedar, Paeschke & Frey Co.
KAWNEER MFG. CO
La Salle Steel Co
Lovett, Walker M., Co.
Rumford Metal Co
So-Luminum Mfg. & Eng. Co
Standard Alloys Co.
Steel Sales Corp.
STEEL PRODUCTS CO
STIMPSON, EDWIN B., CO.
Wheeler, Frank H., & Son

MODEL AIRPLANES

Ideal Aeroplane Supply Co.
Wading River Mfg. Co.

MOTORCYCLES

Excelsior Motor Mfg. Supply Co.
HENDEE MFG. CO.
Harley Davidson Co
Militaire Motor Vehicle Co. of America

OILS AND LUBRICANTS

BAKER CASTOR OIL CO
Graphite Lubricant Co.
Gulf Refining Co.
Sheppard Ideal Oil Co
Sun Co., The
Standard Oil Co.
Swan & Finch
Texas Co., The
Vacuum Oil Co.
WAKEFIELD C. C. & CO., LTD

PACKING

Advance Felt Specialty & Cutting Co.
Booth Felt Co
Fibre Finishing Co.

PHOTOGRAPHY

Brock, Arthur Jr
Herbert & Huesgen Co.

PISTONS

Aluminum Castings Co
Lovett, Walker M., Co.

PISTON RINGS

American Piston Ring Co.

PONTOONS

Niagara Boat Co.
PALMER SIMPSON CO
Welin Marine Equipment Co.

PROPELLERS

AMERICAN PROPELLER & MFG. CO.
American Sash & Door Co.
Aviante Mfg. Co
Breitung & Co., Ltd.
C. M. O. Physical Laboratory
Doyle, W. A.
Flottorp Mfg. Co.
HARTZELL WALNUT PROPELLER CO
JACUZZI BROS
Jamestown Propeller Co
Lang Propeller Co. of America
Staves Sash & Door Co.
Reinforced Propeller & Insulating Co., The
United States Aero Propeller Co.
Washington Aeroplane Co.
WEST WOODWORKING CO

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PYROMETERS
FOXBORO CO., INC., THE
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Shore Instrument & Mfg. Co.
TAYLOR INSTRUMENT COMPANIES

RADIATORS
AJAX AUTO & AERO SHEET METAL CO.
A-S Co.
Bush Mfg. Co.
E Arco Radiators Co.
English & Mersick Co.
FLEXO MFG CO.
Harrison Radiator Co
Livingston Radiator Co.
McCord Mfg. Co.
ROME-TURNEY RADIATOR CO.
STANDARD ROLLER BEARING CO.

RIVETS
STIMPSON, EDWIN B., CO.

SCELEROSCOPE
Shore Instrument & Mfg. Co.

SHEET METAL FITTINGS
BLUM, JULIUS & CO.
Rogers Construction Co.

SHOCK ABSORBERS
DURAL RUBBER CORP
General Rubber Goods Co.
Ohio Rubber Co.
Russell Mfg. Co.
WOOD, J. W., ELASTIC WEB CO.

SPARK PLUGS
Bosch Magneto Co.
Champion Ignition Co
JOHNS-MANVILLE, H. W. CO
Rajah Auto Supply Co.
Sivex Co. The
Splitdorf Electrical Co.

SPEED INDICATORS
FOXBORO CO. INC
JOHNS-MANVILLE, H. W., CO
Stewart-Warner Speedometer Corp.

STABILIZERS
Greene Aeronautical Co.
Martin Aerodynamic Stabilizer.
SPERRY GYROSCOPE CO

STAMPINGS
BLUM, JULIUS & CO.
Enameling & Stamping Corp. of New York
LANSING STAMPING & TOOL CO.
Dewes Co., The A
STIMPSON, EDWIN B., CO.

STARTERS
Bijur Motor Lighting Co.
Bosch Magneto Co.
Christensen Engineering Co., The
Dayton Engineering Laboratories Co.
MOTOR-COMPRESSOR CO.
Northeast Electric Co.
Remy Electric Co
Wagner-Hoyt Electric Co.

TANKS
Janney Steinmetz & Co.

THERMOMETERS
FOXBORO CO., INC., THE
Moto Meter Co
TAYLOR INSTRUMENT COMPANIES

TIRES AND RUBBER
DURAL RUBBER CORP
GOODYEAR TIRE & RUBBER CO.
Hodgman Rubber Co.
United States Rubber Co.
WOOD, J. W., ELASTIC WEB CO
Whitley Exerciser Co.

TOOLS
American Tool Works Co.
Ease Brothers
BLUM, JULIUS & CO.
Brooks Machine Co.
Browne & Sharpe
Buffum Tool Co.
Cooper Aeroplane Co., The John D
GEBB CO
HALL-SCOTT MOTOR CAR CO
HAMMACHER, SCHLEMMER & CO
LANSING STAMPING & TOOL CO
Peck, Stowe & Wilcox Co.
Rich Tool Co.
Rogers Works, John M.
Smith & Hemenway
Whitman & Barnes Mfg. Co.

TRUCKS AND TRAILERS
Federal Motor Truck Co.
Four Wheel Drive Auto Co.
Fruehauf Trailer Co.
Nash Motors Co.
Packard Motor Car Co.
Sechler Company, The
Service Motor Truck Co.
White Company, The

TUBING
American Tube Co
BLUM, JULIUS & CO.
Dewes Co., The A.
Empire Art Metal Co.
Frasse & Co., Peter A.
National Tube Co
Pennsylvania Flexible Metallic Tubing Co
STIMPSON, EDWIN B., CO.

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Aero Mfg. & Accessories Co
Dayton Metal Products Co.
Dillner Meyer Mfg. Co.
ERIE SPECIALTY CO.
National Aeroplane Co.
New York & Hagerstown Metal Stamping Co
STANDARD TURNBUCKLE CO.
STEEL PRODUCTS CO

WHEELS
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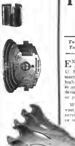
Dayton Wire Wheel Co
Dayco Wheel Co
Mott Wheel Works
NATIONAL WIRE WHEEL WORKS
Spranger Wire Wheel Corp.
Watson Wheel & Rim Corp.
Wire Wheel Corporation of America

WIRE
American Steel & Wire Co.
Century Telephone Construction Co.
Electric Cable Co
NEW YORK WIRE AND SPRING CO
Rathbone, A. R. & J
ROEBLING'S SONS JOHN A.
Simplex Wire & Cable Co.
Upson Walton Co.

WIRELESS
American Radio & Research Corp.
American Wireless Telegraph Co.
Cutting & Washington, Inc.
Crocker-Wheeler Co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